Critical thinking skills in tertiary education in Botswana

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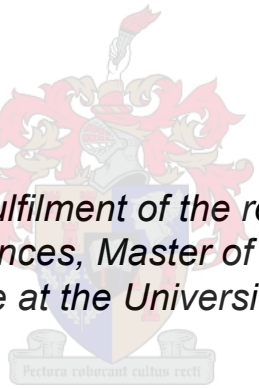

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DECLARATION:

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OPSOMMING

Hierdie tesis wil bydra tot ‘n assessering van kritiese denkvaardighede in tersiêre onderwys in Botswana. Dit is gedoen deur ‘n instrument van analise te ontwikkel wat gebaseer is op die algemeen bekende en gebruikte Bloom se taksonomie van die kognitiewe domein, spesifiek die hersiene taksonomie wat die teoretiese basis vir hierdie tesis is. Hierdie instrument word dan toegepas op ‘n geselekteerde groep jaareind eksamenstelle van ‘n prominente universiteit in Botswana wat spesialiseer in opleiding vir die industrie.

Aanleiding tot die fokus op kritiese denkvaardighede is die algemene behoefte aan innovasie en ontwerp wat tiperend is van die mededingende aard van die kennis-ekonomie, en in besonder die beleidskeuse van die Botswana regering om die ekonomie in die rigting van die sogenaamde 4^{e} industriële revolusie te stuur.

Hoofstuk 1 beskryf die agtergrond van die studie en verduidelik die afbakenings en metodologiese keuses in die studie.

Hoofstuk 2 profileer die konsepte van kritiese denke en kritiese denkvaardighede.

Hoofstuk 3 volg die ontwikkelingsgeskiedenis van Bloom se raamwerk en gaan in diepte in op die hersiene taksonomie

Hoofstuk 4 verduidelik die konstruksie van die instrument van analise, en demonstreer in besonderhede hoe dit toegepas is om die kodering te doen vir die tesis.

Hoofstuk 5 bied die resultate aan van die kodering.

Hoofstuk 6 evalueer die data en kom tot bepaalde gevolgtrekkings. Dit sluit in ‘n bespreking van die noodwendige beperking van die studie en die vraag hoeveel veralgemening moontlik is. Ten minste kan die algemene konklusie gemaak word dat die eksamenstelle ‚n onder verteenwoordiging van kritiese denkvaardighede demonstreer.

Afgesien van die spesifieke resultate van die studie, kan wel gekonstateer word dat die instrument wat ontwikkel het nuttig is om op ‘n gestandaardiseerde wyse kritiese denkvaardighede in vraestelle te meet. As sodanig is dit ‘n bruikbare platform vir ‘n landswye assessering van kritiese denkvaardighede in tersiêre onderwys.

SUMMARY

This thesis seeks to contribute to an assessment of critical thinking skills in tertiary education in Botswana. It does so by developing an instrument of analysis based on the well-known and world widely used Bloom's taxonomy of the cognitive domain, specifically the revised version which is the theoretical basis for this thesis. The instrument of analysis is then applied to a select set of year-end examination papers at a prominent university in Botswana which specializes in training for industry.

The dedicated focus on critical thinking skills is triggered by the general need for innovation and invention brought about by the competitive nature of the knowledge economy, and in particular by the policy decision by the Botswana government to aggressively develop the economy along the route of the 4th industrial economy.

Chapter 1 sets out the background to the study and explains the delimitations of the study and the methodological choices that were made.

Chapter 2 profiles the notions of critical thinking and of critical thinking skills in greater detail.

Chapter 3 traces the history and evolution of the Bloom's framework and explicates the various dimensions of the taxonomy in its revised version.

Chapter 4 explains the construction of the instrument of analysis on the basis of the Bloom's taxonomy and demonstrates the specifics of the application

Chapter 5 presents the findings and draws conclusions on the basis of the data.

Chapter 6 offers evaluations and conclusions. This includes a discussion of the limitations to generalising the study results. It nevertheless can be confidently stated that critical thinking skills are underrepresented in the year-end papers.

Apart from the specific results obtained in this study, it can be stated that the study has developed a standardised instrument of analysis which can be replicated across multiple educational institutions. As such it is a platform on which an education-wide reappraisal of critical thinking skills development in Botswana may be conducted.

Acknowledgements

My sincerest gratitude goes to my Supervisor Prof. Johann Kinghorn for incessantly reigniting my passion for this thesis even at some of my lowest points. Year after year you made me believe in the power of what I had to contribute to the Knowledge Management body of knowledge, and finally that product is here. No amount of thank you' s can truly express the gratitude that fills my heart. I am grateful to my family for their support and their sacrifice of allowing me to steal time I could be spending with them to dedicate it to this thesis. I truly appreciate their constant reminders that I could do it despite the many times I faltered. Above all, I thank my Heavenly Father for His Mercy, Grace and Love, for had these not been in constant supply in my life, this passion of mine would have faded. It is my wish that this thesis contributes in its own special way to both the field of Knowledge Management and to the development of my beloved country Botswana.

TABLE OF CONTENTS

ABBREVIATIONS

BIUST	Botswana International University of Science and Technology
CCTST	California Critical Thinking Skills Test
CCTDI	California critical Thinking Disposition Inventory
WGCTA	Watson-Glaser Critical Thinking Appraisal
CTDS	Critical Thinking Dispositional Scales
APA	American Psychological Association
CT	Critical Thinking
CACCN	Canadian Association of Critical Care Nurses
VaKE	Values and Knowledge
CATA	Computer-aided Text Analysis

FIGURES

TABLES

Chapter 1

The question of critical thinking skills in Botswana

1.1 The education quality debate in Botswana and critical thinking skills

This thesis is an attempt to contribute to an assessment of the extent and level of *critical thinking skills* in tertiary education in Botswana.

The interest in critical thinking skills flows from the belief that the competitive nature of a modern economy (particularly if the intention is to strive toward a knowledge economy) requires, among other things, graduates from tertiary institutions to be capable of critical thinking. It is by now a cliché that a country's competitive advantage in the 21st century depends on its ability to innovate. That this cannot be done without a pool of graduates who are capable of critical thinking (that is higher order thinking) seems to be self-evident.

The interest of this thesis in critical thinking was triggered by the specific context of Botswana. The question of education quality in Botswana has been a public issue for a long time and characterised by a disquiet about the effectiveness of the education system in general economic life. Botswana's efforts to transform her tertiary education sector date back to 2003 with the introduction of the Tertiary Education Policy and a Tertiary Education Council to "increase access to tertiary education, improve quality, ensure relevance of the programmes of study and that, through research and innovation, tertiary education in Botswana becomes a tool for economic diversification and general development."[1]

[1] (Molutsi 2009) Tertiary education reforms in Botswana: Commonwealth Education Partnerships.

The reforms in tertiary education in Botswana saw a proliferation of both Public and Private Tertiary Institutions, resulting in a growth in the gross enrolment ratio in tertiary education from 22,000 in 2006 to 59,091 students in 2017[2].

The heavy focus on quality improvement did not yield the expected results. A background study to developing the National Human Resource Development Strategy cited poor quality of tertiary level programmes as one of the key problems in the Botswana education life cycle[3]. In 2013 a Grant Thornton International Business Report found that 56% of businesses in Botswana cited a lack of skilled workers as a constraint to economic growth.[4] This led to many businesses depending on expatriate workers, which is purported to be a "possible manifestation of the lack of relevance, efficiency and effectiveness in the Botswana training system".[5]

In 2015, the Sunday Standard newspaper reported "over the past few years, government, the private sector and other stakeholders have been spending sleepless nights trying to find ways of amassing a pool of skilled workers who can match the demands of industry. At the moment, the country depends on migrant workers to fill the skills gaps in some professions"[6].

The 2019 Bank of Botswana Quarterly Business Expectations Survey stated that unavailability of skilled labour was one of the major challenges facing businesses in the fourth quarter of 2019.[7]

Meanwhile the notion of a knowledge economy gained ground over the past decade. Recently the idea of the 4th Industrial Revolution captured the imagination as it is leading to the inevitable "transformation of entire systems of production, management, and governance"[8]. As

[2] Human Resource Decelopment Council (Botswana) 2017/18 Annual Report

[3] National Human Resource Development Strategy 2009 – 2022: Ministry of Education and Skills Development (Botswana)

[4] Grant Thornton International Business Report. Global Economy in 2013. The IBR is an annual international survey of more than 10,000 mid-market businesses in over 30 economies.

[5] Ndung'u, V. 2014. An investigation into the influence of culture on employability and work ethic, and the role of tertiary educators on graduates preparedness in Botswana: 1st International Conference on Social Sciences and Humanities.

[6] https://www.sundaystandard.info/botswana-graduates-unemployed-or-unemployable/ accessed 07/05/2020

[7] Bank of Botswana Quarterly Business Expectations Survey 2019. The quarterly survey is undertaken by the reserve bank to anticipate directions of change in the local economy based on the domestic business community's perceptions about the prevailing state of the economy and prospects.

[8] Schwab, K. 2016. The Fourth Industrial Revolution: what it means, how to respond: World Economic Forum

a consequence, the quality debate increasingly shifted to the *skills debate*. In her PhD study of higher education accreditation in Botswana, Phetolo Modiega[9] in fact takes it for granted that already in 2015, the country was on the road toward a knowledge economy and that tertiary education, through the accreditation system, ought to continuously drive that objective[10]. She may have been slightly optimistic in 2015, but after the elections of October 2019 the Botswana government has *formally* declared the development of a knowledge economy in Botswana as its central policy objective[11].

Despite all of the intentions, policies and programmes, the numbers are against Botswana to date. Botswana is ranked 91st out of 141 economies on the Global Competitiveness Index[12]. Of key interest for this thesis are the Skills and Innovation Capability pillars as they have a direct bearing on a country's readiness to transform into a knowledge-based economy. Botswana is ranked 94th and 99th on them respectively as can be seen in Table 1.1.

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[9] Modiega, P. 2015. Development of a programme accreditation system to address quality in tertiary education institutions in Botswana. Pretoria: UP Online

[10] Modiega, P. 2015: "It is prudent that as the programme accreditation evolves it is also modern so as to fit in the transforming knowledge economy and thus be adaptable to global society." (115). Elsewhere she writes: "An effective programme accreditation system would steer the education system towards a knowledge economy in line with aspirations of the nation." (237)

[11] In April 2019, the President Dr Mokgweetsi E.K. Masisi remarked "It is envisaged that Botswana's economy will transform from an upper middle income to a high income status characterised by high levels of productivity, competitiveness, sustainable jobs and achieving a knowledge based economy by the year 2036 as espoused by the national strategy." Daily News (24/04/2019). http://www.dailynews.gov.bw/news-details.php?nid=48897

When announcing the proposed 2020/21 budget of P 51.37 billion in February 2020, the Minister of Finance and Development Planning Dr Thapelo Matsheka stated: "The Ministry of Basic Education is allocated the largest share of the proposed Ministerial recurrent budget amounting to P9.01 billion. This… demonstrates Government's commitment to deliver on the human capital development priority, which is a prerequisite for the transition to a knowledge-based economy." A further P4.89 billion was allocated to the Ministry of Tertiary Education, Research, Science and Technology. Mmegi Newspaper (03/02/2020). https://www.mmegi.bw/index.php?aid=84284&dir=2020/february/03

[12] The Global Competitiveness Report 2019: World Economic Forum.

Botswana				91st/141
Index Component	Value	Score *	Rank/141	Best Performer
6th pillar: Skills 0–100	-	56.8 ↑	94	Switzerland
Current workforce 0–100	-	52.9 ↑	85	Switzerland
6.01 Mean years of schooling years	8.9	59.1 =	79	Germany
Skills of current workforce 0–100	-	46.6 ↑	98	Switzerland
6.02 Extent of staff training 1–7 (best)	4.0	50.1 ↑	68	Switzerland
6.03 Quality of vocational training 1–7 (best)	3.8	46.8 ↓	91	Switzerland
6.04 Skillset of graduates 1–7 (best)	3.5	41.7 ↑	114	Switzerland
6.05 Digital skills among active population 1–7 (best)	3.7	44.9 ↑	103	Finland
6.06 Ease of finding skilled employees 1–7 (best)	4.0	49.7 ↑	90	United States
Future workforce 0–100	-	60.8 ↓	96	Denmark
6.07 School life expectancy years	n/a	68.4 ↓	n/a	Multiple (11)
Skills of future workforce 0–100	-	53.2 ↑	86	Denmark
6.08 Critical thinking in teaching 1–7 (best)	3.3	37.9 ↑	85	Finland
6.09 Pupil-to-teacher ratio in primary education ratio	22.6	68.5 =	86	Multiple (5)
12th pillar: Innovation capability 0–100	-	31.4 ↑	99	Germany
Interaction and diversity 0–100	-	34.3 ↑	102	Singapore
12.01 Diversity of workforce 1–7 (best)	4.6	60.7 ↑	56	Singapore
12.02 State of cluster development 1–7 (best)	3.2	36.3 ↑	116	Italy
12.03 International co-inventions per million pop.	0.00	0.0	126	Multiple (5)
12.04 Multi-stakeholder collaboration 1–7 (best)	3.4	40.2 ↑	100	Israel
Research and development 0–100	-	21.4 ↓	94	Japan
12.05 Scientific publications score	93.7	67.4 ↑	101	Multiple (9)
12.06 Patent applications per million pop.	0.00	0.0	132	Multiple (8)
12.07 R&D expenditures % GDP	0.5	17.9 ↓	58	Multiple (7)
12.08 Research institutions prominence 0–100 (best)	0.00	0.4 ↓	115	Multiple (7)
Commercialization 0–100	-	45.7 ↑	102	Luxembourg
12.09 Buyer sophistication 1–7 (best)	3.0	32.6 ↑	112	Korea, Rep.
12.10 Trademark applications per million pop.	237.00	58.9 ↑	91	Multiple (7)

Table 1.1 – Botswana on the Global Competitive Index[13]

1.2 The research objective

It is against the above backdrop that this thesis ventures into the field of *critical thinking* and *critical thinking skills*. In doing so, the thesis, by implication, expresses the view that the topic of critical thinking is undervalued in the larger debate in Botswana.

There are two dimensions to the objective of this thesis: a substantive and a methodological dimension.

1.2.1 The substantive objective

Few will deny that critical thinking skills are a requirement when the educational objective is to promote innovation and creativity in the classroom and ultimately in the workplace. The

[13] The Global Competitiveness Report 2019: World Economic Forum.

recent policy shift toward an explicit knowledge based economy for Botswana clearly adds impetus to the demand for people with higher order, i.e. critical thinking skills. Although the thesis does not aim to enter into the Botswana debates that were referred to above, a dedicated study on critical thinking skills in Botswana may be a valuable contribution to the broader discourse.

It must be said, however, that achieving innovation, creativity, indeed the knowledge economy, involves more than critical thinking skills. Organisations, government policies and society all have to adapt. There needs to be a socio-political space for critical thinkers to have an impact on innovation. There needs to be political and economic space to absorb innovation into social and business life. And there needs to be sufficient lower order skills to support the higher order economic and business processes. This thesis, therefore, does not focus on the critical thinking dimension as if it is the only silver bullet for Botswana's proposed move to a knowledge economy.

The thesis does start from the assumption, though, that *without a sufficient emphasis* on critical thinking skills, the achievement of a knowledge economy is highly unlikely. This leads directly to the question to what extent and which formats formal education in Botswana inculcates critical thinking in the various syllabi. This question is clearly quite comprehensive and cannot be covered in one study. In this thesis the scope is narrowed down to tertiary education (with further delimitations as are described in section 1.3).

The substantive objective of this thesis, then, is to determine the level and nature of critical thinking skills in actual tertiary education in Botswana.

This objective must be distinguished from any attempt to *develop* (and strategize toward) an ideal model for critical thinking skills education in Botswana. Nor is it the objective to *evaluate* the present quality of critical thinking education from a curricular or didactic point of view, or to assess the efficacy of critical thinking skills education in economic life. What is intended in this study, is to contribute toward a profile, as best as is possible, of the *actual* extent and types of critical skills development in tertiary education in Botswana at the moment. It can, thus, be said that the objective of the thesis is to provide a snapshot of actual critical thinking skills development (in tertiary education in Botswana). But as it will become clear in this thesis, achieving a reliable snapshot is a quite complex matter.

Critical thinking is a complex topic with a conceptual history and a wide-ranging discourse

dating back to at least 1910[14] (and roots much further into the past) which will be discussed in greater detail in chapter 2. There are many perspectives on it, but for the purposes of this thesis, TA Angelo's definition[15] is a sufficient working definition:

> *Most formal definitions characterize critical thinking as the intentional application of rational, higher order thinking skills, such as analysis, synthesis, problem recognition and problem solving, inference, and evaluation.*

1.2.2 The methodological dimension

The above definition makes clear that critical thinking is only a *part* of the cognitive spectrum that formal education should mediate. It comprises the "higher order" cognitive functions. It also implies that higher order thinking skills are always interwoven with lower order and other skills.

It is this "interwovenness" of thinking skills that leads to the second objective of this thesis. In real life thinking is a holistic activity. To describe some aspects of thinking as "critical thinking" is a theoretical abstraction which is not directly evident when one observes real life. It is, therefore, a conceptual challenge, when observing real life (as is the case in this thesis) to find a reliable framework (other than intuition and subjective preference) to identify those abstracts that are termed "critical thinking". In fact, depending on what framework is used, the picture of the actual extent and types of critical thinking skills that can be observed in tertiary education will be different.

In pursuing the aim of presenting a portrait of the extent and nature of actual thinking skills mediated in tertiary education in Botswana, it was, therefore, necessary to establish a credible framework to function as an interpretive instrument to "unweave" the higher order from the lower order thinking skills.

The second objective of this thesis is, therefore, to construct an instrument of analysis to appropriately identify critical thinking skills in a tertiary education context.

With this in mind the specific design, in particular the narrowing down to a coherent and feasible focus of the research project, which is reported on in this thesis, can now be described.

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[14] The Stanford Encyclopedia of Philosophy provides an extensive overview: https://plato.stanford.edu/entries/critical-thinking/

[15] Angelo, T. A. (1995). Beginning the dialogue: Thoughts on promoting critical thinking: Classroom assessment for critical thinking. *Teaching of Psychology*, 22(1), 6-7

1.3 The research design

For its empirical basis this thesis is restricted to one university in Botswana only. In fact, it is restricted to only one activity in the university. There are a number of reasons for this strict delimitation.

1.3.1 Delimitation – logistical feasibility

Botswana is not a populous country. Yet there are a comparatively large number of tertiary institutions. Trying to cover them all is not feasible in a single research project, at least at master's level. The time and resources needed to cover all tertiary institutions cannot be mobilised in one study at master's level.

1.3.2 Delimitation – empirical basis

To compile a comprehensive picture of critical thinking skills development in Botswana, a study that investigates all teaching and learning practices in all tertiary education institutions in the country, is required. This would include all lectures, practicals, group work, assignments and tests, as well as the pedagogical philosophies on curricula development and teaching. Again, this is beyond the capacity of this researcher and the scope of a master's thesis. In fact, such an undertaking would require a major and most likely government sponsored effort.

1.3.3 Delimitation – empirical basis

In this thesis year end examination papers are deemed to be proxies for the broader educational process which culminate in such examinations.

As stated in 1.2 above, the focus of this thesis is to detect the *actual* situation with regard to critical thinking skills development. For this objective a survey-based approach is not suitable. Surveys render responses based on *subjective* views and experiences. Had this study intended to focus on, for instance, the perspectives on critical thinking held by tertiary teaching staff, or the learning experiences of students, a survey would have been indicated. But that is not the focus of this thesis. As the focus of this study is to, as far as possible, gauge the *actual* presence of critical thinking skills development, an approach which yields data by way of *observation* is required.

It is this consideration which led to the choice made in this thesis for the *analysis of examination papers*, in particular end of year papers, as the method of observation.

It is conceded that examination papers represent only a small part of any formal learning process. It can never encapsulate the entire learning experience of any programme. But it is in

the nature of examination papers, particularly end of year papers, to be *representative* of the core content of the module or course and its educational objectives.

Particularly an end of year examination paper, therefore, can be assumed to be a *reasonable proxy* for the core learning objectives of the module or course. It is this special character of examination papers (as opposed to other forms of testing) that makes them the stuff of external evaluation, and at some universities primary evidence of academic standards.

By focusing on examination papers, the criteria of feasibility and coherence are met. It is clearly feasible to analyse a large number of papers – which increases representivity – and the fact that the object of analysis (examination papers) shares the same generic character, guarantees the substantive coherence of the analysis.

1.3.4 Delimitation – ethical integrity

Academic freedom includes an amount of confidentiality and Intellectual Protection. Of all the overt intellectual products of tertiary education, few are in the public domain. These are mostly theses and dissertations, but in some cases year end examination papers become documents in the public domain too.

The university who features in this thesis makes public such examination papers. They are published on the university's WWW pages and are thus deemed to be in the public domain. All documents analysed in this thesis – i.e. year-end examination papers - are open to the public, at least at the time of publishing.

1.3.5 The research focus

When all of the above considerations are taken into account, the focus of this thesis can be formulated as follows:

- the *actual* extent and level in tertiary education in Botswana
- of *higher order skills* development such as analysis, synthesis, problem recognition and solving, inference and evaluation
- as is observable in end of year *examination* papers.

1.4 Methodological considerations

The choice for an approach to achieve the objective of this thesis by means of an analysis of an observable proxy, implies a choice of methods in the field of document analysis. In this case textual and content analysis are the required analytical methods to employ. However, no

document (or genre) is ever analysed outside a clear context. It is, therefore, also necessary to clearly identify the framework which directs the textual and content analysis executed in this thesis. For this purpose, Bloom's taxonomy is used.

1.4.1 Textual and Content Analysis

Content analysis "sees texts as expressions of content" whilst textual analysis relies on linguistics and treats text "as meaning potential out of which actual meanings in context arise".[16] The latter can be applied to "visual, written, or recorded texts to investigate messages portrayed within media, literature, public press, and personal interviews."[17]

In chapter 4 the specific application of both methods is discussed in greater detail.

1.4.2 Interpretive framework – Bloom's taxonomy

All content analysis involves interpretation as shaped by a specific framework. In the case of this thesis the interpretive framework is the notion of critical thinking skills. But, as was alluded to above, critical thinking skills is an abstract notion and literature shows a wide range of approaches to the topic.

To be able to achieve the aim of this thesis, it is necessary to rely on a framework which standardises and synthesises the discourse around critical thinking. For that purpose, the choice was made for the very widely used Bloom's Taxonomy of the Cognitive Domain.

The taxonomy is widely used across the world as the criterion for educational curricula design. In South Africa, for example, it is the basis for all educational curriculum development.

Bloom's Taxonomy is not in itself a framework of critical thinking skills. It is a taxonomy that comprises the totality of cognitive functions in the context of formal learning activities. But precisely for that reason it allows the thesis to distinguish higher order from lower order thinking.

By utilising the taxonomy, it is possible to construct an implementable instrument to evaluate end of year examination papers to determine the level and extent of critical thinking that a paper anticipates from the student.

In chapters 3 and 4 more specific discussions of Bloom's taxonomy are offered.

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[16] Pälli et al., 2012. *Textual Analysis*. The SAGE Encyclopedia of Case Study Research.

[17] Allen, 2017. *Textual Analysis*. The SAGE Encyclopedia of Communication research Methods.

3.5 The choice of examination papers - BIUST

The papers subjected to analysis in this thesis all come from the Botswana International University of Science and Technology (BIUST) online, open-access library.

BIUST describes it mission as follows:

> The Botswana International University of Science and Technology is a Government of Botswana supported institution established through the BIUST Act (CAP 57:05) as a research-intensive University that specialises in Engineering, Science and Technology at both undergraduate and graduate (Master's and Doctoral) levels…. The University is a national strategic initiative that is intended to serve as one of the key platforms for transforming Botswana's economy from being resource based to knowledge based through skills capacity building in Engineering, Science and Technology. Because of its research emphasis, BIUST works with the private sector to meet emerging skills needs of the industry, as well as identifies challenges that can be solved through applied research.[18]

Given this mission statement, locating this study in BIUST makes sense beyond the practical advantage of published examination papers.

Firstly, the emphasis on the ideal of a knowledge economy, makes BIUST a good candidate for an analysis as is offered in this thesis. One would expect a sensitivity for the development of critical thinking skills.

Secondly, as BIUST concentrates on engineering, science and technology – all three of which are highly significant to a knowledge economy – the value for the purpose of this thesis, of an extensive analysis of its examination papers is higher than, for example, analysing subjects from multiple institutions and a wide variety of disciplines.

3.6 The research question

It is now possible to formulate the research question that is pursued in this thesis:

> *When applying textual and content analysis to year end examination papers at BIUST, to what extent and at what levels of Bloom's taxonomy are there evidence of the development of higher order thinking skills in the formal education process?*

[18] https://www.biust.ac.bw/

3.7 Limitations

In the last chapter the limitations of this study will be revisited, looking back on the actual analysis. At this point the following have to be noted:

a) The restriction to one institution only, obviously implies that the results have indicative value, but before they can be generalised countrywide further comparative studies have to be done.
b) Learning is a very complex process, comprising (as Bloom's overall theory of learning shows) much more than cognitive aspects. In the overall learning process, critical thinking is only a sub-category. This study cannot claim, therefore, that critical thinking alone will solve the need for innovation and increased workplace skills. It is, however, generally assumed that critical thinking capability is a necessary component of the required skills.
c) Right now, the world at large is in flux. Education systems are under pressure and it might well be that major changes may occur in the near term. This study, therefore, aims to contribute to the present situation and does not pretend to offer a long-term view. However, it is unlikely that the future will have less need for critical thinking capabilities.

3.8 The thesis in overview

Chapter 2 profiles the notions of critical thinking and of critical thinking skills in greater detail

Chapter 3 traces the history and evolution of the Bloom's framework and explicates the various dimensions of the taxonomy in its revised version

Chapter 4 discusses relevant methodological aspects and applies the instrument of analysis to the selected examination papers

Chapter 5 presents the findings and draws conclusions on the basis of the data

Chapter 6 offers overall conclusions

Chapter 2

Critical Thinking and Critical Thinking Skills

2.1 Introduction

Although critical thinking is a central theme in this thesis, it is not the focus in itself. It is not the intention here to engage in the discourse on the nature and philosophical characteristics of critical thinking. This chapter will only attempt to provide an overview of the most prominent ideas in this regard.

The topic of critical thinking must not be confused with critical thinking *skills.* Of course, there is a direct connection, but the study of the abstract notion of critical thinking is not the same as the study of observable, and perhaps teachable, skills which are deemed to originate from the ability to think critically. As this thesis is situated primarily in the context of tertiary education, the particular skills that are deemed to be critical thinking skills will be the main focus of this chapter.

In the term critical thinking, the word 'critical' has its roots in classical Greek and Greek philosophy. According to Liddel and Scott's Greek-English Lexicon[19] the verb 'krino' encompasses the following: to separate, to choose, to judge, to question, and to examine. Consequently, the noun 'krites' is defined as a person who is a discerner, a judge and an arbiter. The adjective 'kritikos' describes the ability to discern or decide. Derivatives include 'krisis' (meaning separation, choice, judgement) and 'kriterion' (meaning standard, or a means for judging).

Over the years the spectrum of meanings attached to the word 'krino' and its derivatives has

[19] Liddel and Scott's Greek-English Lexicon 1963. OUP

grown. Yet the core notion of judgement and choice remains. This is true also for the derivative of 'criticize' which, although mostly meant negatively, still expresses a choice (not to agree).

It is beyond this thesis to map the whole spectrum of views and theories that have grown over the centuries around the word 'critical' and its derivative 'critical thinking'. This chapter can only provide an overview of the most important literature in this field. It seems best to do so by way of a historical overview. Although ideas in this area can be traced back to, at least, Socrates, it is only since the early 20th century that a true and wide discourse has developed. In fact, a historical overview shows a growing urgency around the notion of critical thinking particularly during the 20th century.

2.2 Early notions of critical thinking

The 1997 publication *California teacher preparation for instruction in critical thinking: Research Findings and Policy Recommendations*[20] offers a very succinct and useful overview. This section draws on this publication for a short overview of thought before 1900.

Some of the earliest thought of critical thinking is attributed to the 5th century BCE Greek philosopher Socrates.[21] Central to his ideas is the teaching methodology known as *Socratic Questioning*, which according to the writings of one of his scholars, Plato[22], is "an education strategy that involves cross-examination of students by their teacher. The teacher assumes the role of an ignorant inquirer who poses a series of questions designed to show that the principal question he raised is one to which his interlocutor has no adequate answer." Socrates believed this type of questioning was central to the stimulation of critical thinking as it led the person being questioned to start asking themselves questions about the validity of their original response.

Fast forward to the thirteenth century when Thomas Aquinas[23] contributed to the notion of

[20] Paul, et al. 1997. California teacher preparation for instruction in critical thinking: Research Findings and Policy Recommendations. https://files.eric.ed.gov/fulltext/ED437379.pdf Accessed 06/05/2020

[21] Kraut, Richard. February 2020. Socrates. Encyclopedia Britannica, Inc. https://www.britannica.com/biography/Socrates Accessed 06/05/2020

[22] Meinwlad, Constance C. March 2020. Plato. Encyclopedia Britannica, Inc. https://www.britannica.com/biography/Plato accessed 06/05/2020

[23] McGill, S.A. 2017. *Thomas Aquinas*, p. 1. http://search.ebscohost.com.ez.sun.ac.za/login.aspx?direct=true&db=f5h&AN=17949003&site=ehost-live&scope=site accessed 07/05/2020

critical thinking by promoting the idea of *considering and responding to criticisms* of one's ideas as a way of ensuring thoughts were well reasoned. He believed that both scientific reason and religious thinking were compatible sources of knowledge and should hence both be relied on in the process of thinking.

In the 16th century Francis Bacon promoted the idea of scientific research and information gathering in his work *The Advancement of Learning.* Around the same time René Descartes in his *Rules for the Discretion of the Mind* developed the idea of "*critical thought based on the principle of systematic doubt."*

The seventeenth and eighteenth centuries were characterised by the contributions of Robert Boyle and Sir Isaac Newton who were respectively responsible for criticism of chemical theory and the traditional world view in that era. From their work developed the notion of basing fact on scientifically gathered evidence and sound reasoning.

2.3 The discourse in the twentieth century – 1900 to 1950

In literature Graham Sumner is mostly seen as the father of the 20th century discourse on critical thinking. Sumner made contributions to the fields of sociology and anthropology where he highlighted the need for *critical thinking in life and education*.[24]

Of the notion of criticism, he remarked in 1902:

> "Criticism is the examination and test of propositions of any kind which are offered for acceptance, in order to find out whether they correspond to reality or not. It is a prime condition of human welfare that men and women should be trained in it. It is our only guarantee against delusion, deception, superstition, and misapprehension of ourselves and our earthly circumstances. Education in the critical faculty is the only education of which it can be truly said that it makes good citizens".[25]

In 1910, John Dewey's work took centre stage in the development of the critical thinking field. Through his pragmatic approach, he sought to reconstruct philosophy such that it was less technical and intellectualistic and more connected to the social conditions and values

[24] Paul, et al. 1997. California teacher preparation for instruction in critical thinking: Research Findings and Policy Recommendations

[25] Sumner, W.G. 1902. *Folkways; A study of the sociological importance of Usages, manners, customs, mores, and Morals*. The Athenaeum Press. http://www.gutenberg.org/files/24253/24253-h/24253-h.htm#Footnote_2214_2214 Accessed 08/05/2020

dominating everyday life.[26] In his renowned text *How we Think*, he remarks of uncritical thinking:

> "If the suggestion that occurs is at once accepted, we have uncritical thinking, the minimum of reflection. To turn the thing over in mind, to reflect, means to hunt for additional evidence, for new data, that will develop the suggestion, and will either, as we say, bear it out or else make obvious its absurdity and irrelevance."

He adds that:

> "The essence of critical thinking is suspended judgment; and the essence of this suspense is inquiry to determine the nature of the problem before proceeding to attempt at its solution. This, more than any other thing, transforms mere inference into tested inference, suggested conclusions into proof."

It is in this publication that he developed critical thinking in relation to research methodology and the search for data and facts in an effort to answer questions truthfully. His proposition was that *suspended judgement* is the foundation of critical thinking as it is only when judgement is suspended that one can go about determining the nature of a problem before attempting to solve it. His explanation emphasised the importance of reflection when seeking information that will add relevance to one's claim, adding that without reflection, one's thinking is uncritical. [27]

Dewey followed up on this topic in later books. In 1916 he published *Essays in experimental Logic,* and in 1938 *Logic: The Theory of Inquiry.* It can be said that he dominated the discourse on the topic in the early part of the 20th century and that his work was seminal to later developments.

2.4 The discourse since 1950

After 1950 there is a clear increase in interest in the notion and practice of critical thinking, in particular with respect to educational implications. This seems to have been a part of the increased focus on the aims of education, and particularly the cognitive dimension, which led to the establishment of the working group chaired by Benjamin Bloom in 1956 in the USA.

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[26] Hildebrand, D. John Dewey. *The Stanford Encyclopaedia of Philosophy* (Winter 2018 Edition), Edward N. Zalta (ed.), https://plato.stanford.edu/archives/win2018/entries/dewey/. Accessed 08 May 2020

[27] Dewey, J. 1910. *How we think.* Heath and Co.

The outcomes of the work of this committee will be the topic of the next chapter.

Subsequently, the number of voices in this field increased. Today virtually all universities have centres for teaching and learning and a large number of them focus on critical thinking. There is also a vast number of definitions[28]. This section offers an overview of the many and diverse contributions.

Norris & Ennis expounded on Dewey's ideas of reflection and judgement by defining critical thinking as reasonable and reflective thinking that is focused on deciding what to believe or do.[29] In this decision-making process, one relies on metacognition and the reasoning procedures of one's discipline in order to inform one's final position on an issue. Well-founded judgment is the absolute goal of critical thinking and there is need to "use appropriate evaluative standards in the attempt to determine the true worth, merit, or value of something".[30]

According to Angelo, critical thinking requires the application of higher order thinking skills of analysis, synthesis, problem recognition and problem-solving, inference, and evaluation.[31]

For Paul and Elder, problem-solving is a tool in critical thinking, and critical thinking too is a tool in problem-solving.[32] "Critical thinking skills are used in every step of the problem-solving process" and "in order to solve problems, one must be able to think critically".

Kurfiss finds critical thinking to be the end-product of an interplay of factors such as "knowledge, skills, cognitive and metacognitive processes, an epistemological stance, and the purposes of the learner". Three types of knowledge are at interplay when one is engaged in critical thinking, namely "declarative knowledge, knowing the facts and concepts in the

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[28] A good example is the University of Tennesee Chattanooga who actively teach critical thinking. On the question: Why teach Critical Thinking? They provide the following answer:
"Oliver & Utermohlen (1995) see students as too often being passive receptors of information. Through technology, the amount of information available today is massive. This information explosion is likely to continue in the future. Students need a guide to weed through the information and not just passively accept it. Students need to "develop and effectively apply critical thinking skills to their academic studies, to the complex problems that they will face, and to the critical choices they will be forced to make as a result of the information explosion and other rapid technological changes". https://new.utc.edu/academic-affairs/walker-center-for-teaching-and-learning/online-resources/ct-ps

[29] Norris & Ennis. 1989. *Evaluating critical thinking.* Pacific Grove.

[30] Paul et al. 1997. California teacher preparation for instruction in critical thinking: Research findings and policy recommendations. California Commission on Teacher Credentialing, Sacramento.

[31] Angelo T.A. 1995. Beginning the dialogue: Thoughts on promoting critical thinking. *Teaching Psychology.*

[32] Paul et al. 1997. California teacher preparation…

discipline; procedural knowledge, knowing how to reason, inquire, and present knowledge in the discipline; and meta-cognition, cognitive control strategies, such as setting goals, determining when additional information is needed, and assessing the fruitfulness of a line of inquiry" [33]. Open-mindedness is particularly key when engaged in investigations because one is able to "explore a situation, phenomenon, question, or problem to arrive at a hypothesis or conclusion about it that integrates all available information and that can therefore be convincingly justified. In critical thinking, all assumptions are open to question, divergent views are aggressively sought, and the inquiry is not biased in favour of a particular outcome".[34]

Kennedy agrees that open-mindedness is key to good critical thinking, and one should explore all perspectives of an issue, engage in productive discussions, and consider everyone's behaviour when dealing with conflict.[35]

In their 2012 book Goodwin and Sommervold stated that a critical thinker should have the abilities to both answer questions and question answers. To do this the critical thinker should be able to rely on reason alone, be open to a broad range of alternatives and viewpoints, accept new evidence, be willing to reassess information and put aside personal biases, and consider all reasonable options.[36]

In order to engage in critical thinking, individuals depend on past experience, the present, changing facts and conditions, and probable developments.[37] Individuals should be able to reason, reflect, and make sound decisions on their own.[38] This suggests that critical thinkers should be able to exercise their judgement about the credibility and reliability of sources of information when carrying out research. A critical thinker should have the abilities of analysis, evaluation and creating, terms which are usually offered as a definition of critical thinking.[39]

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[33] Kurfiss. 1988.. Critical thinking: Theory, Research, Practice, and Possibilities. ASHE-ERIC Higher Education Report Nr. 2. 71

[34] Kurfiss. 1988. Critical thinking…71

[35] Kennedy M.L. 2010. The art of critical thinking. *Information Outlook,* (14)4:31-34.

[36] Goodwin & Sommervold, 2012. Creativity, critical thinking, and communication strategies to increase students' skills….71

[37] De Zafra 1957. Teaching for critical thinking. *The Clearing House,* 31(8):453-456.

[38] Brookhart, 2010. *How to assess higher-order thinking skills in your classroom*. The Association for Supervision and Curriculum Development: Alexandria.

[39] Ennis, 1993. Critical thinking assessment. *Theory into Practice,* 32(3):179-186

When one is able to analyse and synthesise two or more concepts with relative ease, one is deemed to be invoking higher order thinking, or critical thinking.[40] "Most formal definitions characterize critical thinking as the intentional application of rational, higher order thinking skills, such as analysis, synthesis, problem recognition and problem solving, inference, and evaluation".[41] Being able to solve complex problems and make decisions in an ethical manner is also said to be directly related to the cognitive behaviours of analysis, evaluation and creating.[42] It is also suggested that critical thinking is the "application of knowledge (possession of facts) after careful and measured examination of all information and view points, to make decisions that are non-egocentric in nature."[43]

In critical thinking, one makes judgements about the quality of one's thinking (metacognitive process) and one's ability to generate creative solutions. Critical and creative thinking are therefore believed to complement each other,[44] with creative thinking utilising convergent and divergent thinking to produce innovative solutions.[45] Paul & Bailin as cited in Marzano et.al. also propose that "distinguishing between critical and creative thinking is impossible because all good thinking involves both quality assessment and the production of novelty". Of the importance of critical thinking to innovation, it is noted that "applications that are made of mankind's discoveries and inventions are more important than are the discoveries and inventions themselves, mankind now needs to do some critical thinking of an unprecedented quality".[46]

Paul & Elder highlight the core elements that cut across many of the definitions of critical thinking in the following summation:

> "We now recognize that critical thinking, by its very nature, requires, for example, the

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[40] King, et al., undated. Higher order thinking skills…

[41] Angelo T.A. 1995. Beginning the dialogue: Thought on promoting critical thinking. *Teaching Psychology.*

[42] Bouchard, 2011.In full Bloom: Helping students grow using the taxonomy of educational objectives. *The Journal of Physician Assistant Education,* 44-46.

[43] Flores et.al. 2010. Deficient critical thinking skills among college graduates: Implications for leadership. *Educational Philosophy and Theory,* 44(2):212-230.

[44] Marzano, et.al., 1988. *Dimensions of thinking": A framework for curriculum and instruction.* The Association for Supervision and Curriculum Development: Virginia.

[45] King, et al., undated. *Higher order thinking skills.* Educational Services Program.

[46] De Zafra 1957. Teaching for critical thinking. *The Clearing House,* 31(8):453-456.

systematic monitoring of thought, that thinking, to be critical, must not be accepted at face value but must be analysed and assessed for *its clarity, accuracy, relevance, depth, breadth, and logicalness*. We now recognize that critical thinking, by its very nature, requires, for example, the recognition that all reasoning occurs within *points of view* and frames of reference, that all reasoning proceeds from some *goals and objectives*, has *an informational base*, that all data when used in reasoning must be *interpreted*, that interpretation involves concepts that *concepts* entail *assumptions* and that all basic inferences in thought have *implications*. We now recognize that each of these dimensions of thinking need to be monitored and that problems of thinking can occur in any of them."

2.5 The skills of critical thinking

Defining and debating the phenomenon of critical thinking must not be confused with the educational and business need for a clear framework with which critical thinking can be identified, and possibly taught.

It is not surprising, therefore, that there is a significant body of literature which focuses on specific thinking skills, such as a*nalysis*, *interpretation*, *inference*, *explanation*, *evaluation*, and *self-regulation, verbal reasoning*, *argument analysis*, *hypothesis testing*, *likelihood and uncertainty*, and *decision making and problem solving* as being demonstrations of critical thinking [47] / [48].

Paul and Elder approaches this from the point of view *questioning* skills. They list the following dimensions of questioning as criteria to determine the level of critical thinking:

a) ends and objectives,
b) the status and wording of questions,
c) the sources of information and fact,
d) the method and quality of information collection,
e) the mode of judgment and reasoning used,
f) the concepts that make that reasoning possible,
g) the assumptions that underlie concepts in use,

[47] Facione, et.al. 1995. The disposition toward critical thinking. *Journal of General Education,* 44(1):1-25

[48] Halpern, 2013. The Halpern Critical Thinking Assessment: A response to the reviewers. *Inquiry: Critical Thinking Across the Disciplines,* 28(3):28.

h) the implications that follow from their use, and

i) the point of view or frame of reference within which reasoning takes place.[49]

Ennis, on the other hand, outlines a set of dispositions and abilities which he believes helps one in deciding what to believe or do.[50] These dispositions should serve as a set of comprehensive goals for a critical thinking curriculum and its assessment.[51] A disposition is defined as a person's inherent qualities of the mind and character[52]. A disposition cannot be inspected but rather something must happen for the disposition to be revealed. For example, a glass must be struck with a hard object and break into pieces for one to tell that it has a brittleness disposition.[53] Therefore, an opportunity for critical thinking must present itself in order for one to exhibit one's disposition to it. In response to this view Facione et.al.[54] argue that "skills and dispositions are mutually reinforced and, hence, should be explicitly taught and modelled together".

The development of the discourse on critical thinking skills goes back a long time. Already in 1941[55] Edward Glaser published an attempt to measure critical thinking skills. However, the interest in the matter increased towards the end of the 20th century. Consequently, there are now a range of models and tests available.

Below, a number of the most prominent models are briefly outlined.

2.5.1 The Cornell Conditional Reasoning Test, Form X

The Cornell Critical Thinking Test is attributable to R.H. Ennis and J. Millman. The test was designed to test for general critical thinking ability through a series of validated questions.[56]

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[49] Paul et al. 1997. California teacher preparation…

[50] Facione, et.al. 1995. The disposition toward critical thinking

[51] Ennis, 2011. The nature of critical thinking: an outline of critical thinking dispositions and abilities. *Sixth International Conference on Thinking*, 1-8.

[52] Oxford Lexicon 2020. Oxford University Press. https://www.lexico.com/definition/disposition

[53] Ennis, 1996. Critical thinking dispositions: Their nature and assessability. *Information Logic,* 18(2):165-182.

[54] Facione, et.al. 1995. The disposition toward critical thinking

[55] Glaser EM. 1941. *An Experiment in the Development of Critical Thinking,* Teacher's College, Columbia University

[56] Iwaoka et al. 2010. Measuring gains in critical thinking in food science and human nutrition courses: The Cornell Critical Thinking Test, problem-based learning activities, and student journal entries. *Journal of Food Science Education,* 9:2010.

The test is divided into four sections, with the first section testing an individual's ability to describe the effect information may have on a certain hypothesis, and the second section seeking to determine the test-taker's ability to make pronouncements on a source based on the reliability of the information contained therein. The third and fourth sections respectively judge one's ability to determine if a given statement follows from its premises, and whether one can identify assumptions.[57]

2.5.2 The Ennis-Weir Critical Thinking Essay Test - 1985

The Ennis-Weir Critical Thinking Essay Test was developed by Robert Ennis and Eric Weir as a test for critical thinking ability in argumentation. The intent of the test is to assess an individual's critical thinking ability through the manner they appraise an argument and formulate a written response to the same argument.

In the test, the student assesses an eight-paragraph letter to a newspaper editor wherein the author of the letter attempts to support a proposal they are making. The student is then expected to give both a paragraph-specific and holistic evaluation of the arguments. The major uses of the test are in teaching instruction and in research in high school and college. [58]

The competencies assessed in the test are:

a) Getting to the point
b) Seeing the reasons and assumptions
c) Stating one's point
d) Offering good reasons
e) Seeing other possibilities (including other possible explanations)
f) Responding appropriately to and/or avoiding:
   Equivocation, Irrelevance, Circularity, Reversal of if-then (or other conditional) relationship, The Straw Person Fallacy, Overgeneralisation, Excessive scepticism, Credibility problems, the use of emotive language to persuade[59]

2.5.3 The California Critical Thinking Skills Test (CCTST) - 1990

The CCTST was published in 1990 by the California Academic Press as a tool to assess college-

[57] Sternberg, 1986. *Critical thinking: Its nature, measurement, and improvement*. https://files.eric.ed.gov/fulltext/ED272882.pdf

[58] Ennis & Weir, 1985. *The Ennis-Weir Critical Thinking Essay Test.* Midwest Publications: California.

[59] Ennis & Weir, 1985. *The Ennis-Weir Critical Thinking Essay Test.* Midwest Publications: California. (p1)

level critical thinking skills. In its original form it was a 34 multiple-choice test assessing the skills of analysis, evaluation, inference, deductive reasoning, and inductive reasoning.[60] The test now assesses the skills of interpretation, analysis, inference, evaluation, explanation, and self-regulation[61] as depicted below:

Questions to Fire Up Our Critical Thinking Skills	
Interpretation	• What does this mean? • What's happening? • How should we understand that (e.g., what he or she just said)? • What is the best way to characterize/categorize/classify this? • In this context, what was intended by saying/doing that? • How can we make sense out of this (experience, feeling, or statement)?
Analysis	• Please tell us again your reasons for making that claim. • What is your conclusion/What is it that you are claiming? • Why do you think that? • What are the arguments pro and con? • What assumptions must we make to accept that conclusion? • What is your basis for saying that?
Inference	• Given what we know so far, what conclusions can we draw? • Given what we know so far, what can we rule out? • What does this evidence imply? • If we abandoned/accepted that assumption, how would things change? • What additional information do we need to resolve this question? • If we believed these things, what would they imply for us going forward? • What are the consequences of doing things that way? • What are some alternatives we haven't yet explored? • Let's consider each option and see where it takes us. • Are there any undesirable consequences that we can and should foresee?
Evaluation	• How credible is that claim? • Why do we think we can trust what this person claims? • How strong are those arguments? • Do we have our facts right? • How confident can we be in our conclusion, given what we now know?
Explanation	• What were the specific findings/results of the investigation? • Please tell us how you conducted that analysis. • How did you come to that interpretation? • Please take us through your reasoning one more time. • Why do you think that (was the right answer/was the solution)? • How would you explain why this particular decision was made?
Self-Regulation	• Our position on this issue is still too vague; can we be more precise? • How good was our methodology, and how well did we follow it? • Is there a way we can reconcile these two apparently conflicting conclusions? • How good is our evidence? • OK, before we commit, what are we missing? • I'm finding some of our definitions a little confusing; can we revisit what we mean by certain things before making any final decisions?

Source: © 2014 User Manual for the *California Critical Thinking Skills Test*, published by Insight Assessment.

Table 2.1 - Source: Facione, 2015.[62]

[60] Facione, 1990. Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction. Research findings and recommendations prepared for the committee on pre-college Philosophy of the American Philosophical Association. New Jersey. https://philarchive.org/archive/FACCTA accessed 15/06/2020.

[61] Facione, 2015. Critical thinking: What it is and why it counts. *Insight Assessment.*

[62] Facione, 2015. Critical thinking: What it is and why it counts. *Insight Assessment.*

2.5.4 The California Critical Thinking Disposition Inventory (CCTDI) - 1992

The *CCTDI* originally developed by Peter A. and Noreen C. Facione is used to measure ones' predisposition to critical thinking through the administration of a questionnaire containing 75 Likert-type items. The CCTDI identifies *inquisitiveness, open-mindedness, systematicity, analyticity, truth-seeking, critical-thinking self-confidence,* and *maturity* as the critical thinking dispositions and scales upon which to measure whether or not one is pre-disposed to critical thinking. A mark of 50 and above in the test indicates strength in the dispositions.[63] The test has also over the years undergone some validity testing.[64],[65]

2.5.5 The Watson-Glaser Critical Thinking Appraisal (1994)

The Watson-Glaser Critical Thinking Appraisal is considered by many in the business world as the gold standard in tests. It was originally developed by Goodwin Watson and Edward Glaser and adapted over the years. The WGCTA was designed to measure the extent to which examinees need training or have mastered certain critical thinking skills. Over and above being used in educational settings, it is also used by different professions as an employment selection tool. In fact, any quick search on the internet will show a large number of commercial offers in training for success in a Watson-Glaser test.

The Watson-Glaser-Short Form was published in 1994 based on a combination of tests created by the authors since 1925 (Goodwin Watson) and 1937 (Edward Glaser).[66] The appraisal contains a set of five tests which assess an individual's ability to perform tasks using the critical thinking aspects of

- inference,
- recognition of assumptions,
- deduction,
- interpretation and

[63] Facione, et.al. 1995. The disposition toward critical thinking. *Journal of General Education,* 44(1):1-25.

[64] Sosu, 2013. The development of psychometric validation of a critical thinking disposition scale. *Thinking Skills and Creativity,* 9:107-119.

[65] O'Hare et.al. 2015. The validity of critical thinking tests for predicting degree performance: A longitudinal study. *International Journal of Educational Research,* 72:162-172.

[66] Watson & Glaser, 2008. *Watson-Glaser Critical Thinking Appraisal - Manual.* Pearson: Texas.

- evaluation of arguments.[67]

In 2009, Watson and Glaser was revised in an effort to make it more logically appealing and easily interpretable. The revision was necessitated by factor analyses conducted on the original tests which revealed that Inference, Deduction and Interpretation all related to drawing conclusions, whilst Recognition of Assumptions and Evaluation of Arguments remained as singular factors in critical thinking. The revision resulted in what is now known as the RED model, denoted by the representation below.[68]

Figure 2.1 - The RED model of Watson-Glaser[69]

The Hogan-Lovells Critical Thinking Test is a direct derivative of the Watson-Glaser test and it is used in the legal discipline to measure critical thinking and reasoning ability.[70] Recent studies have also applied the Hogan-Lovells test in the medical fraternity.[71]

2.5.6 The Halpern Critical Thinking Assessment (2010)

The Halpern Critical Thinking Assessment developed by Diane F. Halpern assesses critical thinking ability through a questionnaire which measures both the behavioural and motivational components of critical thinking.[72]

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[67] Watson & Glaser, 2008. *Watson-Glaser Critical Thinking Appraisal - Manual.* Pearson: Texas. (p3-4)

[68] Watson & Glaser, 2010. *Watson-Glaser II Critical Thinking Appraisal – Technical Manual and User's Guide.* Pearson: Texas.

[69] Watson & Glaser, 2010. *Watson-Glaser II Critical Thinking Appraisal – Technical Manual and User's Guide.* Pearson: Texas. 2

[70] Hogan Lovells. http://graduates.hoganlovells.com/page/apply/. Accessed 24/05/2020

[71] Zayapragassarazan & Chacko, 2019. A gap analysis of critical thinking skills and attitude toward critical thinking among interns. *International Journal of Health & Allied Sciences*, *8*(3):193-196.

[72] De Bie, H., Wilhelm, P., & van der Mei, H. 2015. The Halpern Critical Thinking Assessment: Toward a

The questionnaire is composed of open-ended and multiple-choice questions which assess five critical thinking skills of:

- verbal reasoning,
- argument analysis,
- hypothesis testing,
- using likelihood and uncertainty, and
- decision-making and problem-solving.[73]

The open-ended questions test the ability of the respondent to use their own words in response to a situation, whilst the multiple-choice questions test the ability to identify the best alternative from a list of possible answers. According the creator of the test, "all questions are embedded in realistic scenarios in order to test how well respondents recognise the need for and apply appropriate critical thinking skills".[74]

2.5.7 The International Critical Thinking Essay Test

This test, costing $1000, was developed by the International Center for Higher Order Thinking[75].

The self-description of the test is as follows:

> "The purpose of the International Critical Thinking Test is to provide an assessment of the fundamentals of critical thinking that can be used with content from any subject. The goal of the test is two-fold. The first goal is to provide a reasonable way to pre- and post-test students to determine the extent to which they have learned to think critically. The second goal is to provide a test instrument that stimulates the faculty to teach their discipline so as to foster critical thinking in the students".

2.5.8 Critical Thinking Dispositional Scales

Some of the contributors to the discourse on critical thinking skills have, over and above

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Dutch appraisal of critical thinking. *Thinking Skills and Creativity,* (17)2015:33-44

[73] Anastasi, 2013. The Halpern Critical Thinking Assessment: A valid assessment of critical thinking? *Inquiry: Critical Thinking Across the Disciplines,* 28(3): 13.

[74] Halpern, D.F. 2013. The Halpern Critical Thinking Assessment: A response to the reviewers. *Inquiry: Critical Thinking Across the Disciplines,* 28(3):28

[75] See http://www.criticalthinking.org/pages/international-center-for-the-assessment-of-higher-order-thinking/589

defining critical thinking skills, defined critical thinking dispositions or propensity[76] for critical thinking.

A 2012 article which described the development and psychometric evaluation of a Critical Thinking Disposition Scale (CTDS) provided a succinct summary of critical thinking dispositions attributed to authors such as Facione for APA Delphi Report[77], Facione and Facione[78], Tishman, Jay and Perkins[79], Halonen[80], Ennis[81], and Halpern[82].

Table 1
Taxonomies of important thinking dispositions.

Author	Year	No. of dispositions	Examples
APA Delphi Report	1990	19	Inquisitiveness; well-informed; alertness to use CT; trust in reasoned inquiry; self-confidence in one's own ability to reason; open-mindedness; flexibility in considering alternatives; understand opinions of others; fair-mindedness; honesty in facing own biases; prudence in making judgments; revise views where change is warranted; clarity in stating concern; working with complexity; diligence in seeking relevant information; reasonableness in selecting and applying criteria; focusing attention on the concern at hand; persistence in face of difficulties; precision
Facione and Facione	1992	7	Inquisitiveness; open-mindedness; systematicity; analyticity; truth-seeking; critical thinking self-confidence; maturity
Perkins, Jay, and Tishman	1993	7	Broad and adventurous; sustain intellectual curiosity; clarify and seek understanding; planful and strategic; intellectually careful; seek and evaluate reasons; metacognitive
Halonen	1995	5	Tentativeness, scepticism; tolerance of ambiguity; appreciation of individual differences; regard for ethical practices
Ennis	1996	12	Seek alternatives and be open to them; endorse a position when it is justified to do so; well-informed; consider other points of view; clear about intended meaning; determine, and *maintain focus* on, the conclusion or question; seek and offer reasons; take into account the total situation; reflectively aware of own beliefs; discover and listen to others' view and reasons; take into account others' feelings and level of understanding; be concerned about others' welfare
Halpern	1998	5	Willingness to engage in and persist at a complex task; habitual use of plans and the suppression of impulsive activity; flexibility or open-mindedness; willingness to abandon non productive strategies in an attempt to self-correct; awareness of social realities so that thoughts can become actions.

Table 2.2 - Development and psychometric validation of a Critical Thinking Disposition Scale[83]

[76] Sosu, 2013. The development of psychometric validation of a critical thinking disposition scale. *Thinking Skills and Creativity,* 9:107-119.

[77] Facione, 1990. Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction. Research findings and recommendations prepared for the committee on pre-college Philosophy of the American Philosophical Association. New Jersey. https://philarchive.org/archive/FACCTA accessed 15/06/2020.

[78] Facione et al. 1995. The disposition toward critical thinking. *Journal of General Education,* 44(1):1-25.

[79] Perkins et al. 1993. Beyond abilities: A dispositional theory of thinking. *Merrill-Palmer Quarterly* 1982:1-21.

[80] Halonen, 1995. Demystifying critical thinking. *Teaching of Psychology*, 22(1):75-81

[81] Ennis, 1996. Critical thinking dispositions: Their nature and assessability. *Information Logic*, 18(2):165-182.

[82] Halpern, 1998. Teaching critical thinking for transfer across domains: Disposition, skills, structure training, and metacognitive monitoring. *American Psychologist, 53*(4):449–455.

[83] Sosu, 2013. The development and psychometric validation of a Critical Thinking Disposition Scale. 108

These scales have been used in the development of some of the critical thinking tests attributable to the respective authors as discussed above.

2.6 Disciplines that draw on critical thinking skills

The importance of critical thinking and the associated skills is illustrated by the multiple disciplines that rely on the different measurement tools and literature that exist, to add quality and relevance to their professions. It is not only a topic of importance for education.

The most obvious discipline that spends considerable time on the topic is Philosophy. The discipline is not possible without the continuous application of critical thinking. Multiple universities have set up units to research and teach critical thinking. Hong Kong University (ranked 26th globally) for example maintains a Critical Thinking Web[84].

Multiple sources in academic literature demonstrate the importance of critical thinking skills in the medical profession. The Canadian Association of Critical Care Nurses (CACCN) identifies critical thinking as a key skill in the nursing profession as it promotes better decision-making amongst nurses, resulting in them providing better patientcare. [85] Researchers also studied the effect on critical thinking skills after a semester-long critical thinking course taken by student pharmacists.[86] Another study at a South African University sought to determine the improvements needed to the curriculum in order to foster the critical thinking skills of radiography students, and recommended that facilitators integrate methods aimed at improving these skills into their teaching styles.[87] One researcher goes further to propose and advocate for the utilisation of articles from the popular press to give medical students practice in identifying a claim made in the article as well as to evaluate the validity of the claim through an evaluation of the evidence.[88]

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[84] https://philosophy.hku.hk/think/

[85] Tanguay, 2012. Critical thinking. *Dynamics of Critical Care*, 23(4):5

[86] Smith et.al., 2019. A semester-long critical thinking course in the first semester of pharmacy school: Impact on critical thinking skills. *Currents in Pharmacy Teaching and Learning,* 11:499-504.

[87] Pieterse, et.al. 2016. Critical Thinking ability of 3rd year radiography students. *Health SA Gesondheid*, 381-390.

[88] Terry, 2012. Assessing critical-thinking skills using articles from the popular press. *Journal of College Science Teaching*. 42(1):66-70

Critical thinking is also regarded as a key skill in Psychology as evidenced by one study which sought to establish which activities in a specifically tailored programme improved the critical thinking skills of Psychology students.[89] Another study advocated for the utilisation of the Values and Knowledge Education (VaKE) model as a teaching approach geared at improving the critical thinking skills and dispositions of Psychology students.[90]

Other disciplines seek to equip future professionals with critical thinking skills. One study found that using a reality-based project as a teaching methodology, enhanced the critical thinking skills of finance students as it created multiple collaboration opportunities for the students and lecturers.[91] Researchers in Botswana sought to determine the differences in critical thinking abilities and dispositions of pre-service and in-service teachers so as to delineate factors that account for their difference.[92] Efforts are also found in language instruction, with one study proposing ways of cultivating critical thinking in teaching Chinese[93], and others exploring the teaching practices utilised to develop the critical thinking of learners in an English language course[94], and whether explicitly teaching critical thinking enhances the skills of the students learning English[95]. The Hogan Lovells Critical Thinking Test bears testament of the importance of critical thinking in the Law profession.[96]

In the pedagogical sphere, one study argues that using teacher-centred (Confucian) approaches

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[89] Saiz et.al. 2015. Collaborative learning supported by rubrics improves critical thinking. *Journal of the Scholarship of Teaching and Learning.* 15(1): 10-19.

[90] Pnevmat nevmatikos et.al., 2019. Promoting critical thinking in higher education through the values and knowledge education (VaKE) method. *Studies in Higher Education,* 44(5):892-901.

[91] Brous, 2017. Real option application project: Enhancing students' analytical and critical thinking skills. *Journal of Financial Education,* 43(1):63-83.

[92] Mogapi, et.al., 2017. Comparative analysis of in-service and pre-service teachers' critical thinking skills; A thematic approach based on the California Critical Thinking Disposition Inventory. *Journal of Education, Society and Behavioural Science.* 23(4):1-12.

[93] Chen, 2018. Research on critical thinking cultivation and college Chinese teaching. *International Conference on Education, Psychology, and Management Science*, 1127-1131.

[94] Belg Belghiti et.al., 2016. Critical thinking development: The case of the English course in the CPGE classes in Meknes, Fes and Kenitra. *Arab World English Journal,* December:106-127.

[95] Soufi, et.al., 2019. Does explicit teaching of critical thinking improve critical thinking skills of English language learners in higher education? A critical review of causal evidence. *Studies in Educational Evaluation*, 60:140-162..

[96] Hogan Lovells. http://graduates.hoganlovells.com/page/apply/.

is not effective in developing critical thinking skills of students.[97] Other researchers propose a group-teaching strategy that uses a project-based constructivist approach, and that this delivery method enhances students' critical thinking and question-posing skills.[98] Through a feminist critique of theories of critical thinking, a study found that gender influenced how students experienced critical thinking, and further discovered that 90% of students identified a critical thinker as being a male.[99]

It is also not surprising to find the pursuit of critical thinking in the sciences given that the origins of critical thinking can be found in the discipline of scientific inquiry. A study in Turkey set out to examine the impact that inquiry-based learning had on the critical thinking dispositions of pre-service Science teachers.[100] Another study argued that is it imperative for Physics students to practice decision-making based on data in order to develop their critical thinking ability.[101] One researcher boldly proposes the use of the Scrabble Board Game as a tool for developing students' critical thinking skills.[102]

2.7 Conclusion – a working definition of critical thinking

Having discussed the history, conceptions, definitions, skills, dispositions, tests, and applications of critical thinking, one can conclude that both a plurality and convergence of thought exists in the contributions of the multiple authors and scholars. For purposes of this thesis, the Facione's description of critical thinking will suffice:

> "We understand critical thinking to be purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based. CT is essential as a tool of inquiry. As such, CT is

[97] Zhao, 2020. Epistemological flashpoint in China's classroom reform: (How) can a 'Confucian do-after-me pedagogy' cultivate critical thinking? *Journal of Curriculum Studies*, 52(1):101-117.

[98] Sasson et.al., 2018.

[99] Danvers, 2018. Who is the critical thinker in higher education? A feminist re-think. *Teaching in Higher Education,* 23(5):548-562.

[100] Arsal, 2017. The impact of inquiry-based learning on the critical thinking dispositions of pre-service science teachers. *International Journal of Science Education,* 39(10):1326-1338.

[101] Holmes et.al. 2015. Teaching critical thinking. *PNAS,* 12(26):11199-11204.

[102] Kobzeva, 2014. Scrabble as a tool for engineering students' critical thinking skills development. *Procedia Social and Behavioral Sciences,* 182:369-374.

> a liberating force in education and a powerful resource in one's personal and civic life. (…). The ideal critical thinker is habitually inquisitive, well informed, trustful of reason, open-minded, flexible, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of criteria, focused on inquiry, and persistent in seeking results which are as precise as the subject and the circumstances of inquiry permit." [103]

But, as has been pointed out above, critical thinking is to be distinguished from critical thinking skills. In this respect Angelo's definition will be sufficient for this thesis:

> Critical thinking involves "the application of higher order thinking skills, such as analysis, synthesis, problem recognition and problem solving, inference, and evaluation."[104]

In the last section of this chapter a number of models that are on offer to actually measure the extent and quality of such "higher order thinking skills" have been profiled. This serves to illustrate how seriously educators and professions regard such skills, and how sought-after people in possession of critical thinking skills are.

However, for the purpose of this thesis, none of the reviewed models are appropriate. All the models above are designed to test the skills level, and type of individuals – who either want to enter a study programme or an employment opportunity. They are, therefore, in the full sense of the word, tests. They are tests which evaluate the *outcome* of an *individual's* critical thinking skills development. This thesis, on the other hand, is interested in the *input* side of the equation. It aims to assess the extent and type of critical thinking that an educational programme anticipates to mediate through its teaching curriculum. None of the models described above can deliver in this respect.

It is for this reason that an alternative framework is required in this thesis. This is the framework known as Bloom's Taxonomy.

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[103] Facione, 2015. Critical thinking: What it is and why it counts. *Insight Assessment.*

[104] Ang Angelo, 1995. Beginning the Dialogue: Thought on promoting critical thinking. *Teaching of Psychology*, 22(1):6-7.

Chapter 3

Bloom's Taxonomy of the Cognitive Domain

3.1 Introduction

Bloom's Taxonomy of the Cognitive Domain came into being in 1956. In that year Professor Benjamin Bloom chaired a team of educationists over a period of twelve months to craft a coherent educational framework. Although this was a national attempt by the United States to formulate a scientific framework for formal education, the outcome of the deliberations has carried the name of the chairman ever since.

The overall framework of learning and learning objectives that the committee formulated, comprises three areas of human consciousness:

- the cognitive,
- the affective and
- the motor dimensions[105].

However, as formal education is primarily focused on the cognitive dimension, it is that aspect of the framework which has dominated discussions ever since 1956. In its most recognisable and summarised form it consists of a taxonomy. Any internet search for "Bloom's" will return

[105] The affective domain includes objectives which describe changes in interest, attitudes, and values whilst the psychomotor is a description of manipulative or motor-skills.

a virtually endless list of websites dealing with the taxonomy, mostly ignoring the other two dimensions.

This thesis too will draw exclusively on Bloom's taxonomy because it has become the most widely used framework on which formal educational curricula are based.

The taxonomy, as with many classification systems, had subsequent improvements, the most notable and widely accepted is the revision done by Lorin Anderson and David Krathwohl (the latter who was involved also in 1956 with the original formulation) in 2001. In fact, in the South African education system, all curriculum development as well as all teaching activities are now strictly categorised with reference to the Revised Bloom's Taxonomy.

Bloom's (revised) taxonomy of the cognitive domain is not in itself a definition of critical thinking skills. It is intended as a framework to classify *all cognitive activities* that ought to operate in any formal learning context. But it is a *taxonomy,* which means that it does portray a ranking – in this case from lower to higher. For that reason, it has become a widely accepted approach to consider (as in this thesis) the higher cognitive actions to be clear expressions of critical (that is, higher order) thinking *skills.* Indeed, when the higher actions are compared to the commercial critical thinking tests, discussed in the previous chapter, a clear conceptual agreement is in evidence.

This chapter offers a description of the evolution of the original and revised taxonomies, and their rationales. It then proceeds to develop an instrument, based on the revised taxonomy, which serves as the framework for the instrument of analysis which will be discussed and employed in chapter 5.

3.2 The original Taxonomy of Educational Objectives

The conceptual roots of Bloom's Taxonomy of Educational Objectives are traceable to a 1948 convention of the American Psychological Association (APA) where Dr Benjamin Bloom and other college examiners, later responsible for the taxonomy, were present. Central to their thoughts was to develop a theoretical framework to ease communication between examiners as they "exchange ideas and materials among themselves and other persons concerned with educational research and curriculum development"[106]. Moreover, the developers of the taxonomy believed it could serve as a "basis for determining for a particular course or

[106] Bloom et al. 1956. *Taxonomy of education objectives: The classification of educational goals.* Longmans: London.

curriculum the specific meaning of broad educational goals; means for determining the congruence of educational objectives, activities, and assessments in a unit or curriculum; and panorama of the range of educational possibilities against which the limited breadth and depth of any particular educational course or curriculum could be contrasted".[107]

Amidst the plethora of descriptions of curricula such as those describing teacher behaviour, instructional methods and intended pupil behaviour, the consensus of the team was to design the taxonomy so that it is "a classification of the student behaviours which represent the intended outcomes of the educational process". The consensus was also influenced by the generalisability of the behaviours in that they could be observed in different subjects and at all levels of one's schooling life.

The principles that governed the development of the taxonomy were that the agreed categories be associated with those already being used by teachers in curriculum planning, that simple and consistent terms are used to define the categories, and that the taxonomy does not depart from conventional psychological principles and theories. The categories would be definitions of educational objectives, or how students are expected to be transformed by learning, and the objectives would also serve as a reference point when designing evaluation instruments meant to gauge student leaning. The team noted in their reasoning that "a test of the achievement of students is a test of the extent to which the students have attained these educational objectives. An achievement test is an adequate and valid test if it provides evidence of the extent to which students are attaining each of the major objectives of the unit of instruction."[108]

3.2.1 The components of the original taxonomy

The taxonomy in its entirety was conceived as having three main domains. However, Dr Bloom and his team paid more attention to the development of the cognitive domain which classifies behaviours related to the recognition of knowledge.

The original Cognitive Taxonomy was structured as shown in figure 3.1.

The arrangement of the categories was that of increasing complexity, noting that "problems requiring knowledge of principles and concepts are correctly answered more frequently than problems requiring both knowledge of the principle and some ability to apply it in new

[107] Krathwohl, 2002. A Revision of Bloom's Taxonomy: An overview. *Theory into Practice,* 41(4):212.

[108] Bloom et al. 1956. *Taxonomy of education objectives…*28

situations"[109]. The developers of the taxonomy also highlighted that all the cognitive abilities are defined with the assumption that knowledge was a prerequisite in all of them. It is with knowledge that students will be able to use facts and information and select the appropriate techniques for dealing with novel problems. The committee noted that the latter skill is also known as critical thinking[110].

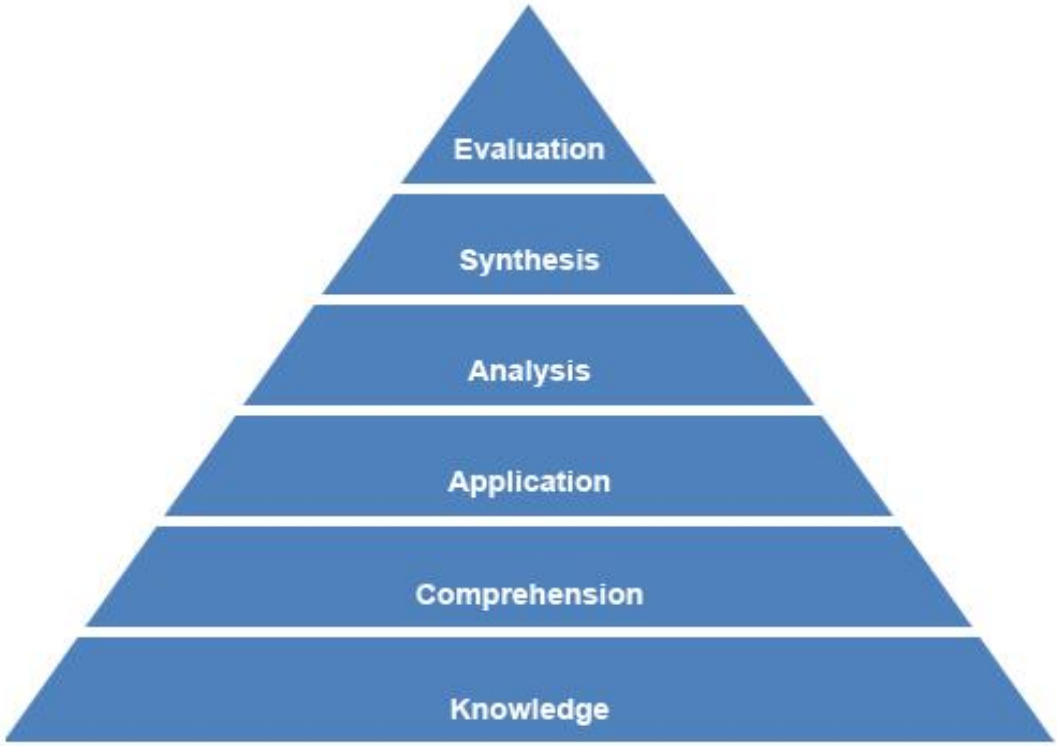

Figure 3.1 - Bloom's original taxonomy of the cognitive dimension in 1956[111]

The six cognitive abilities were further split into two sections, the first part representing the simple behaviour related to remembering facts and information, and the second part representing the more intricate activities of cognition. This translated into the cognitive ability of Knowledge falling into the first part of the taxonomy, whilst Comprehension, Application, Analysis, Synthesis, and Evaluation fell into the second, complex part of the taxonomy.

The developers of the taxonomy noted that "frequently knowledge is the primary, sometimes

[109] Bloom et al. 1956. *Taxonomy of education objectives…*19

[110] Bloom et al. 1956. *Taxonomy of education objectives…*p22

[111] University of Central Florida Faculty Center for Teaching and Learning. https://fctl.ucf.edu/teaching-resources/course-design/blooms-taxonomy/

almost the sole kind of educational objective in a curriculum"[112].

3.2.2 The logic of the original taxonomy

In table format the logic of the original taxonomy is as follows:

Objective	Definition	Sub-objective
1. Knowledge	Remembering by recognition or recall of ideas, material or phenomena.	1.1. Knowledge of specifics 1.2. Knowledge of ways and means of dealing with specifics 1.3. Knowledge of the universals and abstraction in a field
Intellectual abilities and skills		
2. Comprehension	Type of understanding where an individual can make use of information being communicated without necessarily relating it to other material.	2.1. Translation 2.2. Interpretation 2.3. Extrapolation
3. Application	The use of abstractions in particular and concrete situations	
4. Analysis	Breaking down communication into its constituent parts so as to make explicit the hierarchy and relations of ideas.	4.1. Analysis of elements 4.2. Analysis of relationships 4.3. Analysis of organisational principles
5. Synthesis	Assembling elements in order to form a pattern that is new or was not visible before.	5.1. Production of a unique communication 5.2. Production of a plan, or proposed set of operations 5.3. Derivation of a set of abstract relations
6. Evaluation	Making judgements about the value of material and methods for given purposes.	6.1. Judgements in terms of internal evidence 6.2. Judgements in terms of external criteria

Table 3.1 - Bloom's Taxonomy of Educational Objectives[113]

3.3 The Revision of Bloom's Taxonomy

The original taxonomy is no more in use.

In 2001, Lorin Anderson and David Krathwohl set about to revise the original taxonomy to

[112] Bloom et al. 1956. *Taxonomy of education objectives*…28

[113] Bloom et al. 1956. *Taxonomy of education objectives*…201-207

compensate for several shortcomings they had identified. In addition to the reasoning of the original developers, the authors of the revised taxonomy posited that classification of objectives helped to provide a frame of reference for educators which "increases precision and, most important, promotes understanding".[114]

The revision of the taxonomy saw three major shifts, over and above being renamed *A Taxonomy of Learning, Teaching, and Assessing*. The revision resulted in shifts in emphasis, terminology, and the structure of the taxonomy.[115]

With respect to emphasis, the taxonomy was revised to enable use in planning curricula, instruction, and assessments, and ensuring all three are aligned. It defines in detail both the categories and their subcategories as opposed to the original framework which focused only on descriptions of the subcategories.

This made it possible for teachers at all levels to use it, as opposed to the emphasis on higher education in the original taxonomy. Included in the revision are sample assessment tasks as a means of aiding understanding.

In the sections below, changes to the terminology and the structure are discussed in greater detail.

3.3.1 Changes to the structure

The revision resulted in a two-dimensional framework as opposed to the one dimensional original.

The two dimensions are the *knowledge dimension* and the *cognitive process dimension*.

The cognitive process dimension is identified by the verb used to define the objective, whilst the knowledge dimension is identified by the noun used in defining the objective.

The following graphic by Rex Heer from Iowa State University Center for Excellence in Learning and Teaching[116] illustrates the new structure:

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[114] Anderson et al. 2001. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives.* Longmans: New York.

[115] Anderson et al. 2001. *A Taxonomy for Learning, Teaching, and Assessing*…263

[116] Heer, R. Center for Excellence in Learning and Teaching. Iowa State University. https://www.celt.iastate.edu

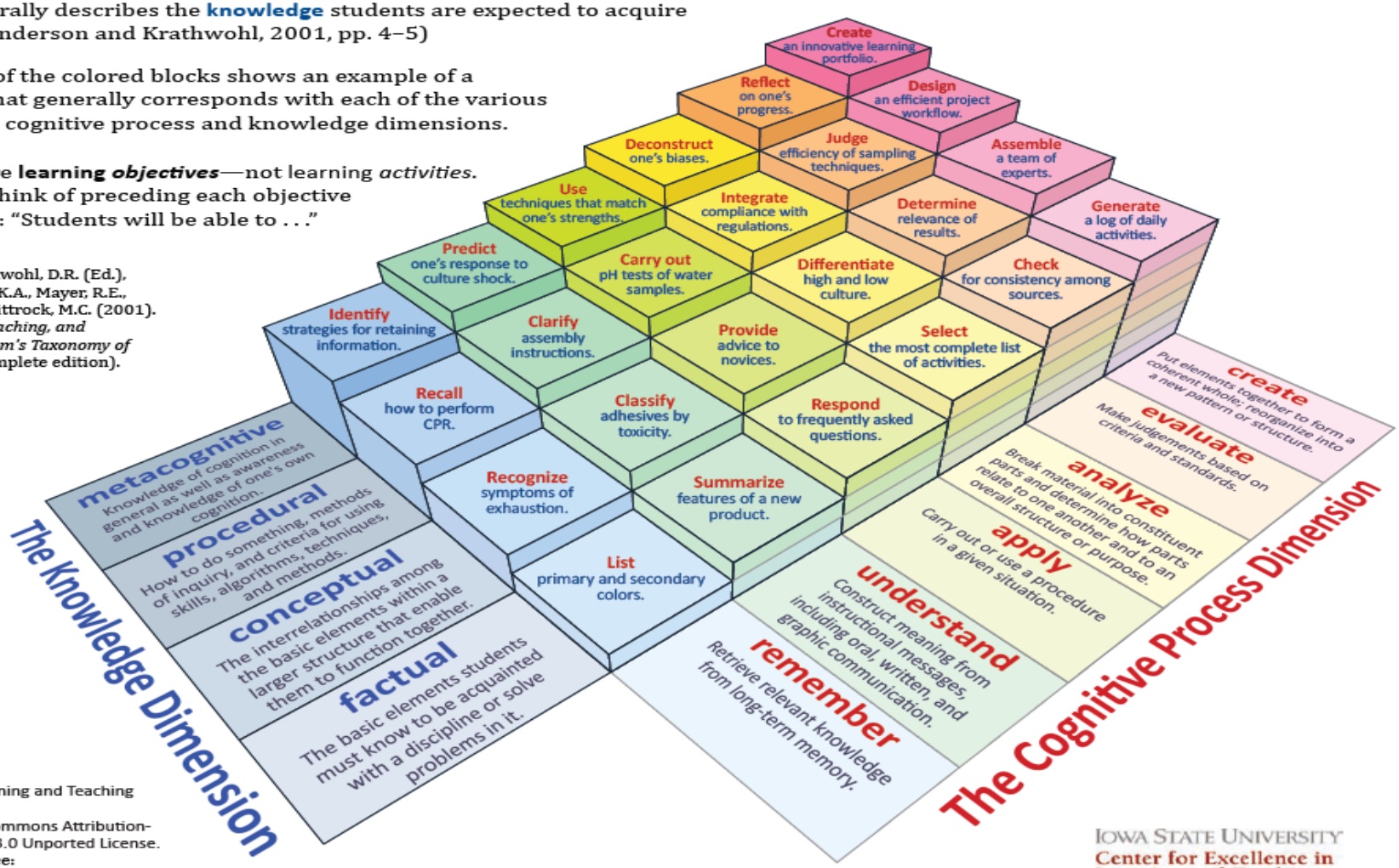
A statement of a **learning objective** contains a **verb** (an action) and an **object** (usually a noun).

- The **verb** generally refers to [actions associated with] the intended **cognitive process**.
- The **object** generally describes the **knowledge** students are expected to acquire or construct. (Anderson and Krathwohl, 2001, pp. 4–5)

In this model, each of the colored blocks shows an example of a learning objective that generally corresponds with each of the various combinations of the cognitive process and knowledge dimensions.

Remember: these are **learning *objectives***—not learning *activities*. It may be useful to think of preceding each objective with something like: "Students will be able to . . ."

*Anderson, L.W. (Ed.), Krathwohl, D.R. (Ed.), Airasian, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., & Wittrock, M.C. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of Educational Objectives* (Complete edition). New York: Longman.



Model created by: Rex Heer
Iowa State University
Center for Excellence in Learning and Teaching
Updated January, 2012

For additional resources, see:
www.celt.iastate.edu/teaching/RevisedBlooms1.html

IOWA STATE UNIVERSITY
Center for Excellence in Learning and Teaching

Figure 3.2 – Iowa State University representation of the revised Bloom's taxonomy

As the illustration shows, the *cognitive process dimension*, which lies along the x-axis of the classification, was re-defined to contain six *processes*:

- Remember,
- Understand,
- Apply,
- Analyse,
- Evaluate and
- Create.

The *knowledge dimension*, which lies along the y-axis was divided into conceptual knowledge categories:

- Factual,
- Conceptual,
- Procedural and
- Metacognitive.

To emphasise the continuum in the two dimensions, the cognitive processes are listed according to increasing complexity. For example, Evaluate is cognitively more complex than Analyse and less complex that Create. Similarly, the knowledge dimension is arranged to demonstrate the continuity of knowledge from concrete to abstract. This is to say that factual knowledge is concrete as it is based on unchanging facts, whilst procedural knowledge is more abstract and prone to change and different interpretations (as for example, different means can be used to achieve the same end), with the effect that a particular procedure may be susceptible to modifications. Metacognitive knowledge is entirely abstract.

3.3.2 Changes to the terminology

The first change in terminology was relabelling the cognitive processes to verb forms in order to use them consistently when constructing objectives related to the cognitive process. This change was meant to cater for the verb-noun relationship in an object, which is defined in the form of "a student should be able to do something (verb representing cognitive activity) with something (noun representing knowledge dimension)"[117]. This was a major change from the original taxonomy which identified all the cognitive processes in noun form. The intention of

[117] Anderson et al. 2001. *A Taxonomy for Learning, Teaching, and Assessing*…265

the change is to "represent cognitive processes incorporated within cognitive theory and research" and to reflect "the type of processes commonly encountered in statements of objectives and unit plans of teachers"[118]. Thus, interpretation and inference were changed to interpreting and inferring respectively, comprehension to understand, and synthesis to create.

These changes are reflected in the separation of the verbs and nouns along the two dimensions; the verbs are along the cognitive process dimension, and the nouns along the knowledge dimension.

The figure below presents an overview of the changes:

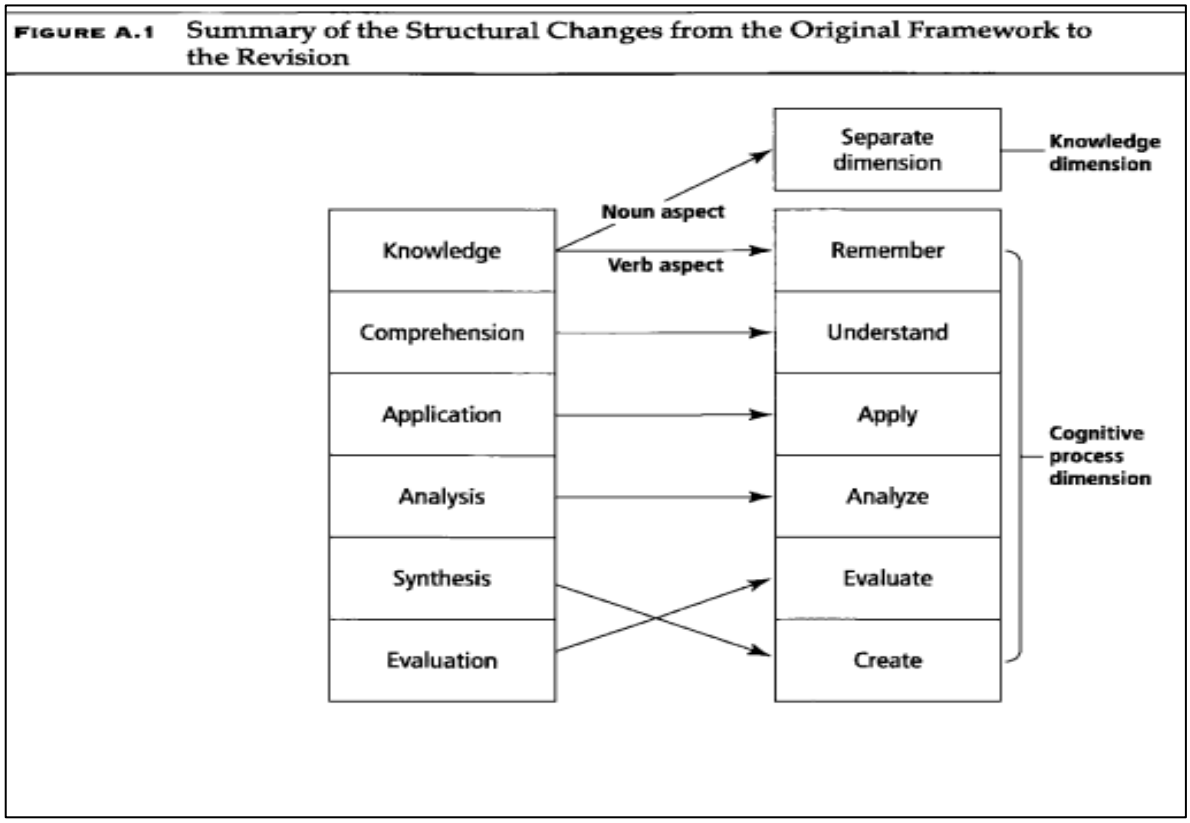


Figure 3.3 - Overview of the structural changes to the original taxonomy[119]

Whereas the original taxonomy presented the cognitive abilities as distinct and being in a cumulative hierarchy requiring mastery of a less complex ability before proceeding to a more complex one, the revised taxonomy describes the categories as a hierarchy along a continuum where overlapping may occur in some instances. For example, in the revision, "the subcategories that define the limits of the *Understand* category are allowed to overlap *Apply*"

[118] Anderson et al. 2001. *A Taxonomy for Learning, Teaching, and Assessing*…266.

[119] Anderson LW Krathwohl DR, et al. 2001. *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*…268.

[120].

Figure 3.3 shows another significant change regarding the top two categories. Previously ranked as Synthesis and Evaluation, the revised taxonomy changes them to Evaluate and Create while changing the sequence as well.

3.4 Components of the Taxonomy of Teaching, Learning and Assessing

The result of the revision of Bloom's Taxonomy as described in the previous section is depicted in the three-dimensional graphical model in Figure 3.2. The colour coded model depicts the cognitive process dimension and related processes in red letters, whilst the knowledge dimension and the knowledge to be constructed is depicted in blue letters. At the intersection of each cognitive process and knowledge dimension are sample learning objectives that instructors may use to support student learning, but also in designing the learning activities and determining their objectives.[121]

The following sub-section is a description of the dimensions of the revised framework.

3.4.1 The Knowledge dimension

The knowledge dimension of the revised taxonomy contains four categories namely factual, conceptual, procedural and metacognitive knowledge. It is important to note that metacognitive knowledge did not exist in the original taxonomy.

The 4 knowledge dimensions play a definitive role in the application of the taxonomy. For that reason, it is best to quote Anderson and Krathwohl directly and extensively:

a) Factual knowledge

The authors describe factual knowledge as follows:

> "Factual knowledge encompasses the basic elements that experts use in communicating about their academic discipline, understanding it, and organizing it systematically. These elements are usually serviceable to people who work in the discipline in the very form in which they are presented; they need little or no alteration from one use or application to another. Factual knowledge contains the basic elements students must know if they are to be acquainted with the discipline or to solve any of the problems

[120] Anderson et al. 2001. *A Taxonomy for Learning, Teaching, and Assessing*…p267

[121] https://pdfs.semanticscholar.org/4948/720587affcdef39c05b8175a0c58e4f05490.pdf?_ga=2.151287738.2031760462.1589549096-986143377.1589549096

in it. The elements are usually symbols associated with some concrete referents, or "strings of symbols" that convey important information. For the most part, Factual knowledge exists at a relatively low level of abstraction.

Because there is a tremendous wealth of these basic elements, it is almost inconceivable that a student could learn all of them relevant to a particular subject matter. As our knowledge increases in the social sciences, sciences, and humanities, even experts in these fields have difficulty keeping up with all the new elements. Consequently, some selection for educational purposes is almost always required. For classification purposes, Factual knowledge may be distinguished from Conceptual knowledge by virtue of its very specificity; that is, Factual knowledge can be isolated as elements or bits of information that are believed to have some value in and of themselves. The two subtypes of Factual knowledge are knowledge of terminology (Aa) and knowledge of specific details and elements (Ab)[122]."

b) Conceptual knowledge

The authors describe conceptual knowledge as follows:

"Conceptual knowledge includes knowledge of categories and classifications and the relationships between and among them - more complex, organized knowledge forms. Conceptual knowledge includes schemas, mental models, or implicit or explicit theories in different cognitive psychological models. These schemas, models, and theories represent the knowledge an individual has about how a particular subject matter is organized and structured, how the different parts or bits of information are interconnected and interrelated in a more systematic manner, and how these parts function together. For example, a mental model for why the seasons occur may include ideas about the earth, the sun, the rotation of the earth around the sun, and the tilt of the earth toward the sun at different times during the year. These are not just simple, isolated facts about the earth and sun but rather ideas about the relationships between them and how they are linked to the seasonal changes. This type of conceptual knowledge might be one aspect of what is termed "disciplinary knowledge," or the way experts in the discipline think about a phenomenon - in this case the scientific explanation for the occurrence of the seasons.

[122] Anderson et al. 2001. *A Taxonomy for Learning, Teaching, and Assessing*…45

Conceptual knowledge includes three subtypes: knowledge of classifications and categories (Ba), knowledge of principles and generalizations (Bb), and knowledge of theories, models, and structures (Be). Classifications and categories form the basis for principles and generalizations. These, in turn, form the basis for theories, models, and structures. The three subtypes should capture a great deal of the knowledge that is generated within all the different disciplines.[123]"

c) Procedural knowledge

The authors describe procedural knowledge as follows:

"Procedural knowledge is the "knowledge of how" to do something. The "something" might range from completing fairly routine exercises to solving novel problems. Procedural knowledge often takes the form of a series or sequence of steps to be followed. lt includes knowledge of skills, algorithms, techniques, and methods, collectively known as procedures …. Procedural knowledge also includes knowledge of the criteria used to determine when to use various procedures. In fact, as Bransford, Brown, and Cocking (1999) noted, not only do experts have a great deal of knowledge about their subject matter, but their knowledge is "conditionalized" so that they know when and where to use it. Whereas Factual knowledge and Conceptual knowledge represent the "what" of knowledge, procedural knowledge concerns the "how." In other words, Procedural knowledge reflects knowledge of different "processes," whereas Factual knowledge and Conceptual knowledge deal with what might be termed "products." lt is important to note that Procedural knowledge represents only the knowledge of these procedures…. In contrast to Metacognitive knowledge (which includes knowledge of more general strategies that cut across subject matters or academic disciplines), Procedural knowledge is specific or germane to particular subject matters or academic disciplines. Accordingly, we reserve the term Procedural knowledge for the knowledge of skills, algorithms, techniques, and methods that are subject specific or discipline specific. In mathematics, for example, there are algorithms for performing long division, solving quadratic equations, and establishing the congruence of triangles. In science, there are general methods for designing and performing experiments. In social studies, there are procedures for reading maps, estimating the age of physical artifacts, and collecting historical data. In language arts,

[123] Anderson et al. 2001. *A Taxonomy for Learning, Teaching, and Assessing*…48

there are procedures for spelling words in English and for generating grammatically correct sentences. Because of the subject-specific nature of these procedures, knowledge of them also reflects specific disciplinary knowledge or specific disciplinary ways of thinking in contrast to general strategies for problem solving that can be applied across many disciplines[124]."

d) Metacognitive knowledge

The authors describe metacognitive knowledge as follows:

"Metacognitive knowledge is knowledge about cognition in general as well as awareness of and knowledge about one's own cognition. One of the hallmarks of theory and research on learning since the publication of the original Handbook is the emphasis on making students more aware of and responsible for their own knowledge and thought. This change cuts across different theoretical approaches to learning and development from neo-Piagetian models, to cognitive and information processing models, to Vygotskian and cultural or situated learning models. Regardless of their theoretical perspective, researchers generally agree that with development students will become more aware of their own thinking as well as more knowledgeable about cognition in general, and as they act on this awareness they will tend to learn better. The labels for this general developmental trend vary from theory to theory but include metacognitive knowledge, metacognitive awareness, self-awareness, self-reflection, and self-regulation…. An important distinction in the field is between knowledge of cognition and the monitoring, control, and regulation of cognition…. In Flavell's (1979) classic article on metacognition, he suggested that metacognition included knowledge of strategy, task, and person variables. We have represented this general framework in our categories by including students' knowledge of general strategies for learning and thinking (strategic knowledge) and their knowledge of cognitive tasks as well as when and why to use these different strategies (knowledge about cognitive tasks). Finally, we include knowledge about the self (the person variable) in relation to both cognitive and motivational components of performance (self-knowledge)[125]."

A summary of the structure of the Knowledge Dimension is presented below:

[124] Anderson et al. 2001. *A Taxonomy for Learning, Teaching, and Assessing*…52

[125] Anderson et al. 2001. *A Taxonomy for Learning, Teaching, and Assessing*…55

Structure of the Knowledge Dimension of the Revised Taxonomy

A. ***Factual Knowledge*** – The basic elements that students must know to be acquainted with a discipline or solve problems in it.

- **Aa. Knowledge of terminology**
- **Ab. Knowledge of specific details and elements**

B. ***Conceptual Knowledge*** – The interrelationships among basic elements within a larger structure that enable them to function together.

- **Ba. Knowledge of classification and categories**
- **Bb. Knowledge of principles and generalizations**
- **Bc. Knowledge of theories, models, and structures**

C. ***Procedural Knowledge*** – How to do something: methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.

- **Ca. Knowledge of subject-specific skills and algorithms**
- **Cb. Knowledge of subject-specific techniques and methods**
- **Cc. Knowledge of criteria for determining when to use appropriate procedures**

D. ***Metacognitive Knowledge*** – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition

- **Da. Strategic knowledge**
- **Db. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge**
- **Dc. Self-knowledge**

Table 3.2 – Structure of the revised Knowledge Dimension[126]

3.4.2 The Cognitive Process Dimension

The cognitive process dimension focuses on the cognitive activities that characterise the learning process.

A very simplified, but handy summary of the structure of the cognitive process dimension is given below:

[126] Krathwohl DR, 2002. A review of Bloom's taxonomy: an overview. *Theory into Practice* 41/4. 214

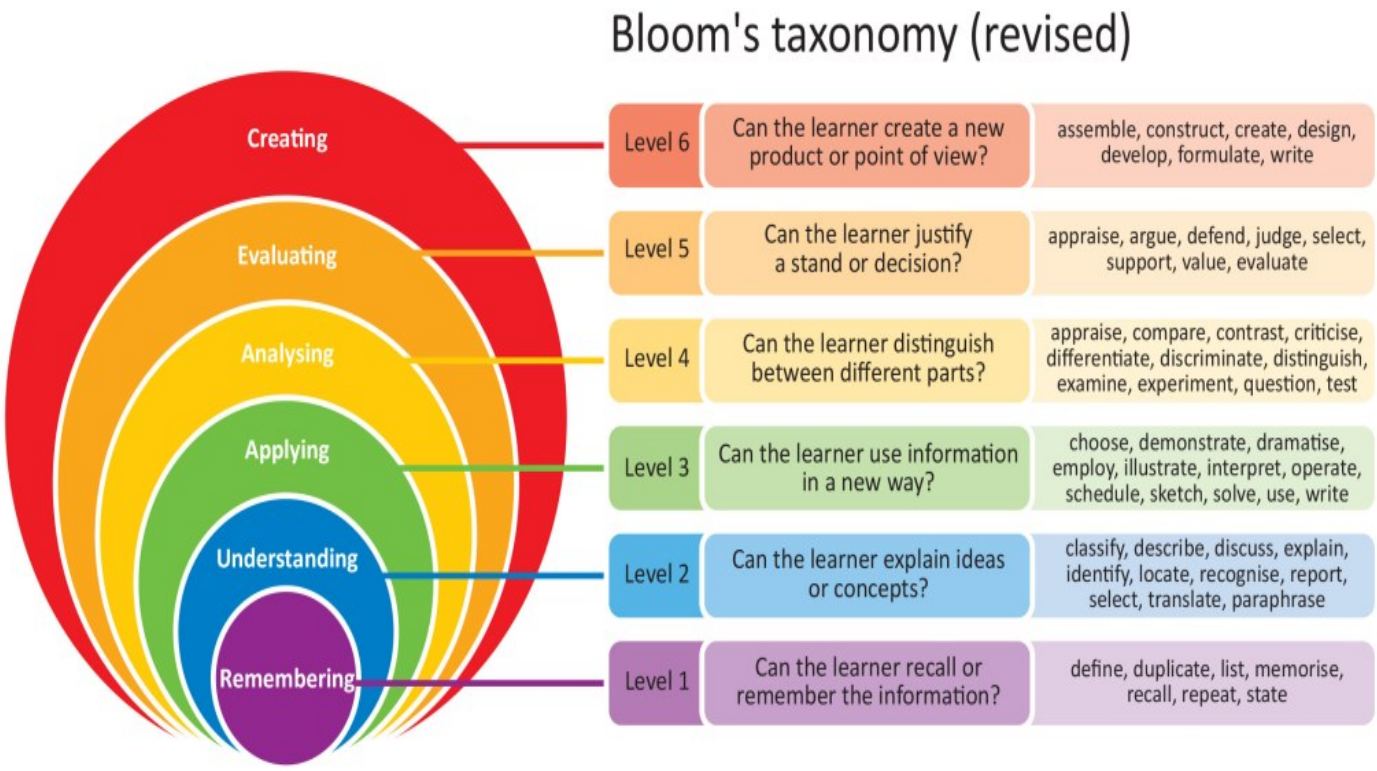


Figure 3.5 - Bloom's revised taxonomy – the cognitive process dimension[127]

The full and formal description is summarised by Anderson and Krathwohl in Table 3.3 which was extracted from that publication.

Below, brief annotations to the 6 processes are offered.

a) Remember

As a cognitive process, remember involves retrieving information from memory. Remembering serves as a cognitive process upon which all the subsequent processes depend. Remembering cuts across all the knowledge categories, meaning a student may be prompted to remember facts, remember concepts, remember procedures, or remember some aspect of cognition.

Remembering is associated with two sub-processes, namely recognising and recalling. Memorizing requires one to "retrieve relevant knowledge from long-term memory in order to compare it with presented information". Recalling involves simply "recalling relevant knowledge from long-term memory".[128]

[127] McNullty N, 2019. Introduction to Bloom's Revised Taxonomy. https://www.niallmcnulty.com/2019/12/introduction-to-blooms-taxonomy.

[128] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...69

5.1 THE COGNITIVE PROCESS DIMENSION

CATEGORIES & COGNITIVE PROCESSES	ALTERNATIVE NAMES	DEFINITIONS AND EXAMPLES
1. REMEMBER—Retrieve relevant knowledge from long-term memory		
1.1 RECOGNIZING	Identifying	Locating knowledge in long-term memory that is consistent with presented material (e.g., Recognize the dates of important events in U.S. history)
1.2 RECALLING	Retrieving	Retrieving relevant knowledge from long-term memory (e.g., Recall the dates of important events in U.S. history)
2. UNDERSTAND—Construct meaning from instructional messages, including oral, written, and graphic communication		
2.1 INTERPRETING	Clarifying, paraphrasing, representing, translating	Changing from one form of representation (e.g., numerical) to another (e.g., verbal) (e.g., Paraphrase important speeches and documents)
2.2 EXEMPLIFYING	Illustrating, instantiating	Finding a specific example or illustration of a concept or principle (e.g., Give examples of various artistic painting styles)
2.3 CLASSIFYING	Categorizing, subsuming	Determining that something belongs to a category (e.g., concept or principle) (e.g., Classify observed or described cases of mental disorders)
2.4 SUMMARIZING	Abstracting, generalizing	Abstracting a general theme or major point(s) (e.g., Write a short summary of the events portrayed on a videotape)
2.5 INFERRING	Concluding, extrapolating, interpolating, predicting	Drawing a logical conclusion from presented information (e.g., In learning a foreign language, infer grammatical principles from examples)
2.6 COMPARING	Contrasting, mapping, matching	Detecting correspondences between two ideas, objects, and the like (e.g., Compare historical events to contemporary situations)
2.7 EXPLAINING	Constructing models	Constructing a cause-and-effect model of a system (e.g., Explain the causes of important 18th-century events in France)
3. APPLY—Carry out or use a procedure in a given situation		
3.1 EXECUTING	Carrying out	Applying a procedure to a familiar task (e.g., Divide one whole number by another whole number, both with multiple digits)
3.2 IMPLEMENTING	Using	Applying a procedure to an unfamiliar task (e.g., Use Newton's Second Law in situations in which it is appropriate)

5.1 THE COGNITIVE PROCESS DIMENSION (CONTINUED)

CATEGORIES & COGNITIVE PROCESSES	ALTERNATIVE NAMES	DEFINITIONS AND EXAMPLES
4. ANALYZE—Break material into its constituent parts and determine how the parts relate to one another and to an overall structure or purpose		
4.1 DIFFERENTIATING	Discriminating, distinguishing, focusing, selecting	Distinguishing relevant from irrelevant parts or important from unimportant parts of presented material (e.g., Distinguish between relevant and irrelevant numbers in a mathematical word problem)
4.2 ORGANIZING	Finding coherence, intergrating, outlining, parsing, structuring	Determining how elements fit or function within a structure (e.g., Structure evidence in a historical description into evidence for and against a particular historical explanation)
4.3 ATTRIBUTING	Deconstructing	Determine a point of view, bias, values, or intent underlying presented material (e.g., Determine the point of view of the author of an essay in terms of his or her political perspective)
5. EVALUATE—Make judgments based on criteria and standards		
5.1 CHECKING	Coordinating, detecting, monitoring, testing	Detecting inconsistencies or fallacies within a process or product; determining whether a process or product has internal consistency; detecting the effectiveness of a procedure as it is being implemented (e.g., Determine if a scientist's conclusions follow from observed data)
5.2 CRITIQUING	Judging	Detecting inconsistencies between a product and external criteria, determining whether a product has external consistency; detecting the appropriateness of a procedure for a given problem (e.g., Judge which of two methods is the best way to solve a given problem)
6. CREATE—Put elements together to form a coherent or functional whole; reorganize elements into a new pattern or structure		
6.1 GENERATING	Hypothesizing	Coming up with alternative hypotheses based on criteria (e.g., Generate hypotheses to account for an observed phenomenon)
6.2 PLANNING	Designing	Devising a procedure for accomplishing some task (e.g., Plan a research paper on a given historical topic)
6.3 PRODUCING	Constructing	Inventing a product (e.g., Build habitats for a specific purpose)

Table 3.3 – Structure of the revised Cognitive Process Dimension[129]

[129] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...67/68

b) Understand

Understanding happens when learners build "connections between the "new" knowledge to be gained and their prior knowledge. More specifically, the incoming knowledge is integrated with existing schemas and cognitive frameworks." Understanding is most strongly associated with conceptual knowledge[130].

Understanding is performed through the sub-processes of interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining. Interpreting is being able to present information in a manner different to how it was learnt, for example defining one's own terms to define a word. Exemplifying is being able to give an example of a concept. Classifying occurs when one allocates an example to a concept. Summarizing involves explaining a concept in fewer words than how it was presented. Inferring refers to the ability to single out a pattern from different bits of presented information. Comparing means being able to single out and present differences and similarities found in presented information. Explaining refers to the ability of attributing certain occurrences to certain causes.[131]

c) Apply

As will be seen in chapter 5 the category of Apply occurred in a fair number of papers. For that reason, this category is dealt with in more detail here.

Anderson and Krathwohl define Apply as "using procedures to perform exercises or solve problems. Thus, apply is closely linked with Procedural knowledge. An exercise is a task for which the student already knows the proper procedure to use, so the student has developed a fairly routinized approach to it. A problem is a task for which the student initially does not know what procedure to use, so the student must locate a procedure to solve the problem."

Applying comprises the subprocesses of executing and implementing. The authors describe the two types as follows:

"In executing, a student routinely carries out a procedure when confronted with a familiar task (i.e., exercise). The familiarity of the situation often provides sufficient clues to guide the choice of the appropriate procedure to use. Executing is more frequently associated with the use of skills and algorithms than with techniques and methods .... Skills and algorithms have two qualities that make them particularly amenable to executing. First, they consist of a

[130] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...70

[131] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...70 - 76

sequence of steps that are generally followed in a fixed order. Second, when the steps are performed correctly, the end result is a predetermined answer. An alternative term for executing is carrying out.

Implementing occurs when a student selects and uses a procedure to perform an unfamiliar task. Because selection is required, students must possess an understanding of the type of problem encountered as well as the range of procedures that are available. Thus, implementing is used in conjunction with other cognitive process categories, such as Understand and Create. Because the student is faced with an unfamiliar problem, he or she does not immediately know which of the available procedures to use. Furthermore, no single procedure may be a "perfect fit" for the problem; some modification in the procedure may be needed. Implementing is more frequently associated with the use of techniques and methods than with skills and algorithms.... Techniques and methods have two qualities that make them particularly amenable to implementing. First, the procedure may be more like a "flow chart" than a fixed sequence; that is, the procedure may have "decision points" built into it.... Second, there often is no single, fixed answer that is expected when the procedure is applied correctly. The notion of no single, fixed answer is especially applicable to objectives that call for applying conceptual knowledge such as theories, models, and structures, where no procedure has been developed for the application."[132]

d) Analyse

"Analyze involves breaking material into its constituent parts and determining how the parts are related to one another and to an overall structure". Analyse is sometimes regarded as an extension of understanding, or the beginning of evaluating[133].

Subprocesses related to analysing are differentiating, organising, and attributing.

Differentiating, although related to the subprocess of comparing (understanding), differs in that the learner filters out and focuses on the important information. This requires the ability to distinguish the parts of a whole in terms of their relevance.

Organising refers to the ability to construct a frame of reference from different bits of information. This usually happens along with the subprocess of differentiating.

Attributing is an extension of the understanding subprocess of inferring in that the leaner also

[132] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...76/78

[133] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...79

indicates the point of view of the information, and the biases and values that may be influencing the information.[134]

e) Evaluate

"Evaluate is defined as making judgments based on criteria and standards. The criteria most often used are quality, effectiveness, efficiency, and consistency. They may be determined by the student or by others. The standards may be either quantitative or qualitative".[135]

Evaluate is characterised by the subprocesses of checking and critiquing. In checking, the concern is with "testing for *internal* inconsistencies in an operation or a product", whilst with critiquing the concern is with testing "a product or operation based on externally imposed criteria and standards". [136]

f) Create

Create is regarded as the highest order thinking skill in the taxonomy. As will be seen in chapter 5, Create was subject to special scrutiny in this thesis. Therefore, a more detailed description of this category is presented here.

"Create involves putting elements together to form a coherent or functional whole. [This entails making] a new product by mentally reorganizing some elements or parts into a pattern or structure not clearly present before. The processes involved in Create are generally coordinated with the student's previous learning experiences. Although Create requires creative thinking on the part of the student, this is not completely free creative expression unconstrained by the demands of the learning task".[137]

With regard to the relationship between Create and the skills that support its, the authors state: "Although the process categories of Understand, Apply, and Analyze may involve detecting relationships among presented elements, Create is different because it also involves the construction of an original product. Unlike Create, the other categories involve working with a given set of elements that are part of a given whole; that is, they are part of a larger structure the student is trying to understand. In Create, on the other hand, the student must draw upon elements from many sources and put them together into a novel structure or pattern relative to

[134] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...80 - 82

[135] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...83

[136] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...84

[137] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...85

his or her own prior knowledge. Create results in a new product, that is, something that can be observed and that is more than the student's beginning materials. A task that requires Create is likely to require aspects of each of the earlier cognitive process categories to some extent, but not necessarily in the order in which they are listed in the Taxonomy Table."[138] In other words, the originality of the constructed product is what differentiates create from the other subprocesses falling under understand, apply, and analyse.

Create is executed through the subprocesses generating, planning, and producing.

Firstly, on generating the authors state that it "involves representing the problem and arriving at alternatives or hypotheses that meet certain criteria. Often the way a problem is initially represented suggests possible solutions; however, redefining or coming up with a new representation of the problem may suggest different solutions. When generating transcends the boundaries or constraints of prior knowledge and existing theories, it involves divergent thinking and forms the core of what can be called creative thinking.... Understand also requires generative processes, which we have included in translating, exemplifying, summarizing, inferring, classifying, comparing, and explaining. However, the goal of Understand is most often convergent (that is, to arrive at a single meaning). In contrast, the goal of generating within Create is divergent (that is, to arrive at various possibilities). An alternative term for generating is hypothesizing".[139]

Secondly, planning is the next step in the creative process. "Planning involves devising a solution method that meets a problem's criteria, that is, developing a plan for solving the problem. Planning stops short of carrying out the steps to create the actual solution for a given problem. In planning, a student may establish sub goals, or break a task into subtasks to be performed when solving the problem. Teachers often skip stating planning objectives, instead stating their objectives in terms of producing, the final stage of the creative process. When this happens, planning is either assumed or implicit in the producing objective. In this case, planning is likely to be carried out by the student covertly during the course of constructing a product (i.e., producing). An alternative term is designing."[140]

Thirdly, "producing involves carrying out a plan for solving a given problem that meets certain

[138] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*... 85

[139] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...86

[140] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...87

specifications.... Objectives within the category Create may or may not include originality or uniqueness as one of the specifications. So, it is with producing objectives. Producing can require the coordination of the four types of knowledge described in Chapter 4. An alternative term is constructing."[141]

From the brief descriptions above, it is evident that the cognitive process dimension consists of several layers in the taxonomy. The top layer consists of the 6 core concepts that are listed above. This is followed by a second layer of sub-concepts. A third layer is present within each sub-concept in the form of a number of descriptions of cognitive processes that are indicative of the sub-concept as well as the core concept.
The Center for Excellence in learning and Teaching at Iowa State University compiled a table that synthesises the different layers. This is shown in Table 3.4 below:

[141] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...87/8

Table 2. The Cognitive Processes dimension — categories & cognitive processes and alternative names

lower order thinking skills → higher order thinking skills

remember	understand	apply	analyze	evaluate	create
recognizing • identifying recalling • retrieving	interpreting • clarifying • paraphrasing • representing • translating exemplifying • illustrating • instantiating classifying • categorizing • subsuming summarizing • abstracting • generalizing inferring • concluding • extrapolating • interpolating • predicting comparing • contrasting • mapping • matching explaining • constructing models	executing • carrying out implementing • using	differentiating • discriminating • distinguishing • focusing • selecting organizing • finding coherence • integrating • outlining • parsing • structuring attributing • deconstructing	checking • coordinating • detecting • monitoring • testing critiquing • judging	generating • hypothesizing planning • designing producing • constructing

(Table 2 adapted from Anderson and Krathwohl, 2001, pp. 67–68.)

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Center for Excellence in Learning and Teaching

Table 3.4- Core terminology of the Cognitive Process dimension

3.5 Applications of the taxonomy

The commonly found uses of the taxonomy is that of classifying learning objectives[142],[143], in developing and assessing instructional instruments[144], and in developing and assessing assessment activities[145],[146]. Ideally, of course it should be used to align the objectives, the instructional activities and the assessments[147].

As such it is a very versatile framework and can be applied to any or all of the above foci. To illustrate this, a few examples of actual usage of the framework are briefly given.

One study used the taxonomy to evaluate the objectives of an English curriculum and related examination questions and their alignment to the taxonomy.[148] The taxonomy was used to provide a methodology of both analysing and discovering the impact of course competencies on curriculum design.[149]

One study in Korea used the framework to classify the outcomes of a newly introduced outcome-based curriculum at a medical school[150]. A similar type of study analysed learning outcomes in an Electrical Engineering curriculum in a in South African university[151].

A different application of the taxonomy led to a three-pronged study to find out the conceptions of lower-order and higher-order thinking held by pre-service mathematics teachers, that is whether they categorized the six cognitive levels at the lower-order and higher-order thinking

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[142] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...

[143] Krathwohl, 2002. A review of Bloom's taxonomy: an overview. *Theory into Practice* (41) 4:214

[144] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...

[145] Ferguson, 2002. Using the revised taxonomy to plan and deliver team-taught, integrated, thematic units. *Theory into Practice*, 41(4):238-243.

[146] Airasian et al. 2002. The role of assessment in the revised taxonomy. *Theory into Practice*, 41(4):249-254.

[147] Anderson LW, Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...

[148] Kozikoglu, 2018. The examination of alignment between national assessment and English curriculum objectives using revised Bloom's taxonomy. *Educational Research Quarterly,* 41(4):50-77.

[149] Gottipati, 2017. Competency analytics tool: Analyzing curriculum using course competencies. *Education and Information Technologies,* 23:41-60.

[150] Yeo, 2019. An analysis of verbs used in the course outcomes of outcome-based integrated courses at a medical school based on the taxonomy of educational objectives. *Korean Journal of Medical Education,* 31(3):261-269.

[151] Meda et al. 2017. Analysing learning outcomes in an Electrical Engineering curriculum using illustrative verbs derived from Bloom's Taxonomy. *European Journal of Engineering Education,* 43(3):399-412.

levels correctly and whether they were able to make the correct identification of test questions that were included in the lower-order and higher-order thinking.[152] In a similar type of study the taxonomy was used to categorise essay questions in an undergraduate medical program in order to determine if they tested for lower order, middle order, or higher order thinking skills.[153] A slightly varied study used the taxonomy to assess the extent to which questions in Social Studies textbooks gave rise to higher-order cognitive domain skills.[154] One study applied the taxonomy in the form of what they called a "cognitive game" to determine the cognitive levels that engineering professors use at different stages of teaching design courses in a university.[155]

The taxonomy has also been used in a study to gauge the knowledge collaboration effect of research and development project teams. The taxonomy was used as a tool for quantifying the factors that influence knowledge collaboration between team members.[156]

The taxonomy has further been used to "propose a scalable quantitative approach to evaluate alignment within and between courses and programs in higher education for benchmarking purposes".[157] Since the more common classifications of examination questions according to the taxonomy are in the cognitive domain, a more recent study proposes a method of classifying questions which fall in all the three domains of the taxonomy, being the cognitive, the affective, and the psychomotor.[158] Another study proposes the use of the taxonomy and its structure of increasing cognitive complexity to apply it to the curriculum of a design-for-sustainability course. The design of the course emphasizes a developmental approach identical to the one

[152] Samo, 2017. Pre-service mathematics teachers' conception of higher-order thinking level in Bloom's Taxonomy. *Journal of Mathematics Education*, 6(2):121-136.

[153] Edussuriya et al. 2018. Evaluation of the cognitive level of essay questions of an undergraduate medical program in Sri Lanka, using bloom's taxonomy. *Sri Lanka Journal of Medicine*, 27(1):3–10.

[154] Tarman et al. 2015. Examination of the Cognitive Level of Questions in Social Studies Textbooks and the Views of Teachers Based on Bloom Taxonomy. *Educational Sciences: Theory & Practice*, 15(1): 13–222.

[155] Sharunova et al. 2018. Transdisciplinary design education for engineering undergraduates: mapping of bloom's taxonomy cognitive domain across design stages, *Procedia CIRP*, 70:313-318.

[156] Wang, 2017. Method for analyzing the knowledge collaboration effect of R&D project teams based on Bloom's taxonomy. *Computers & Industrial Engineering*, 103:158-167.

[157] Nkhoma, et al. 2017. Unpacking the revised Bloom's taxonomy: developing case-based learning activities. *Education and Training,* 59(3):250-264.

[158] Mohammed et al. 2020. Question classification based on Bloom's taxonomy cognitive domain using modified TF-IDF and word2vec. *PLoS ONE*, 15(3):1-21. *Motivation and Understanding,* 65-116. New Jersey

found in the taxonomy, from less complex and concrete, to more complex and abstract.[159]

The taxonomy is also utilised in the medical field. For instance, one study examines the effect of training nurses in thinking activities according to the taxonomy, and thereafter assessing the impact the training had on the manner in which they understood patient situations through interpretation of patient data they had at their disposal.[160] The taxonomy is even used to define the core cognitive skills that are required for research.[161]

3.6 Conclusion: Critical thinking skills and the taxonomy

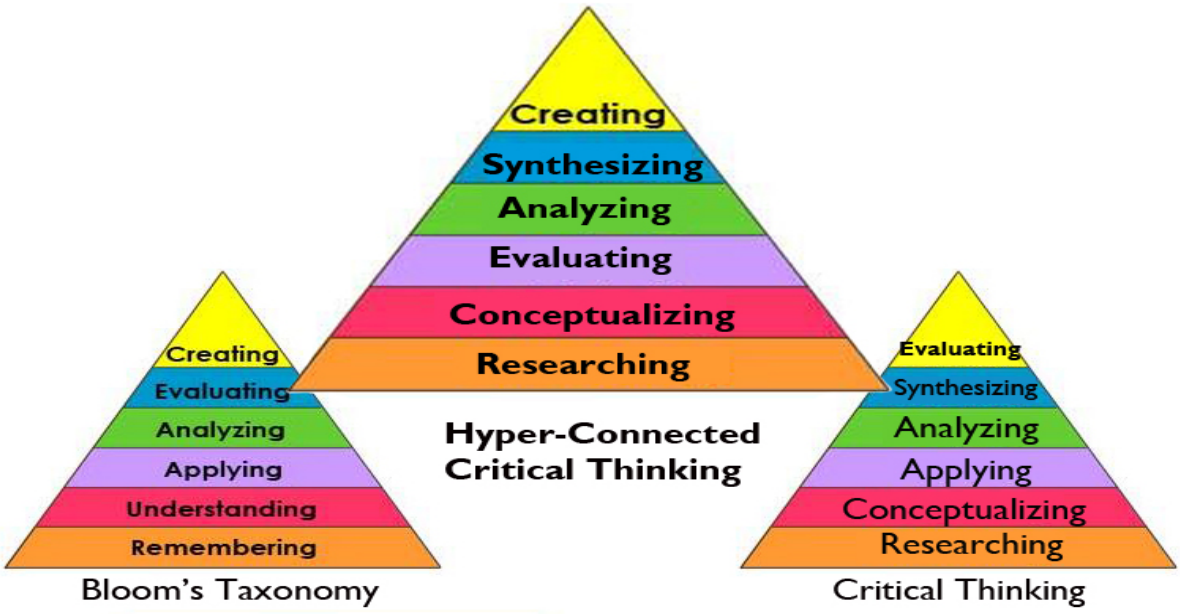
Having concluded with a working definition of critical thinking skills in chapter 3, it is now important to link it with the cognitive abilities of the taxonomy in order to demonstrate why the taxonomy was identified as the best tool to conduct the textual analysis and taxonomical classification of examination papers.

The definition of the word 'critical' suggests purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference. It involves "the application of higher order thinking skills, such as analysis, synthesis, problem recognition and problem

[159] Pappas et al. 2013. Using Bloom's taxonomy to teach sustainability in multiple contexts. *Journal of Cleaner Production,* 48:54-64.

[160] Larkin et al. 2008. Evaluating a case study using Bloom's taxonomy of education. *Association of perioperative Registered Nurses Journal,* 88(3):390-402.

[161] Staff writers, 2013. Applying Hyper-connected Critical Thinking in Higher Education. https://www.onlineuniversities.com



solving, inference, and evaluation". Higher order thinking occurs when new and existing information are "interrelated and rearranged and extended to achieve a purpose or find possible answers in perplexing situations".[162] These skills are invoked when a student is required to "evaluate or compare concepts, model or analyse a hypothesis, and synthesize or design a prototype".[163] In higher order thinking, students are expected to be able to use concepts to solve unfamiliar problems, reflecting the importance of higher order thinking in innovation. Higher-order skills involve application, analysis, evaluating and creating.[164]

When teaching critical thinking, the goal is to enable learners to be able to reason, reflect, and make sound decisions on their own.[165] The definition of critical thinking suggests analysis, evaluation and creating as being key abilities in the process, and these three are often offered as a definition of critical thinking.[166] Applying procedural knowledge through analysis and synthesis of two or more concepts is deemed as higher order of critical thinking.[167] Solving complex problems and making decisions in an ethical manner are also directly related to the cognitive behaviours of analysis, evaluation and creating.[168] We can therefore map critical thinking skills or higher order thinking skills directly to the cognitive abilities of analyse, evaluate and create of the revised taxonomy.

What the above references illustrate is that the top 4 levels of Bloom's taxonomy of the cognitive process is broadly considered to express critical thinking *skills*. Note, for instance, in Table 3.4 the direction of the arrow at the top. In this, the Center for Excellence in Learning and Teaching at Iowa State University echoes the broad assumption of levels 3 to 6 being higher order skills.

The revised version of Bloom's taxonomy introduced, however, a second factor which

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[162] Lopez et al. 2014. Higher-order thinking in a college course: a case study. *NACTA Journal*, *58*(1):73+

[163] Swart, 2010. Evaluation of final examination papers in engineering: A case study using Bloom's taxonomy. *IEEE Transactions on Education,* 53(2):257-264.

[164] Pegg, 2010. *Promoting the acquisition of higher order skills and understandings in primary and secondary mathematics. Teaching Mathematics? Make it Count*.

[165] Brookhart, 2010. *How to Assess Higher-Order Thinking Skills in Your Classroom.* The Association for Supervision and Curriculum Development (ASCD): Alexandria.

[166] Ennis, 1993. Critical Thinking Assessment. *Theory into Practice,* 32(3):179-186.

[167] King et al. undated. *Higher Order Thinking Skills.* Educational Services Program.

[168] Bouchard, 2011. In full Bloom: Helping students grow using the Taxonomy of Educational Objectives. *The Journal of Physician Assistant Education,* 22(4):44-46.

significantly sharpens the cognitive process taxonomy. This is the classification of knowledge types. It allows for a far more sophisticated mapping of a particular skill to a particular type of knowledge.

There is also a measure of ranking in the knowledge classification with factual knowledge an easier cognitive task than metacognition. It can be said that the ranking, in this case, lies on a continuum of concrete to abstract. This correlates with the levels of the cognitive process taxonomy, in that the higher thinking process skills that is required, the more abstraction is involved.

It is this correlation that provides this thesis with a solid framework for the evaluation and classification of each question in an exam paper. How this is translated into an instrument of analysis, is discussed in the next chapter.

Chapter 4

The construction and implementation of the instrument of analysis

4.1 Introduction

This chapter is devoted to the appropriation of Bloom's Revised Taxonomy for the purpose of creating a credible assessment instrument.

In the previous chapter the versatility of the Bloom's paradigm has been accentuated. The available literature on the use of the taxonomy, however, covers mainly the "input" side, that is the design of curricula and lecture content. For the purposes of this thesis, the taxonomy has to be used from the "output" side. What is needed is an instrument which reads *back* from the examination papers to the cognitive and knowledge objectives that are present in the examination papers by implication.

The development of the revised version of the taxonomy does contain some help in reading backwards, but it still clearly demands independent interpretation by the researcher of the examination papers. The chapter, therefore, starts with a discussion of interpretation by means of textual and content analysis.

Then follows a section that describes the structuring of the instrument by using the two dimensional model that was developed by Iowa State University.

In the final section demonstrates how the interpretation activity was fused into the framework of the instrument of analysis, including concrete examples of the actual coding of the papers.

4.2 Methodological considerations

Analysing examination papers by applying Bloom's taxonomy involves interpretation. In fact, it is an activity that will be classified in terms of Bloom's as the cognitive process of evaluation.

Since examination papers are essentially texts, it is evident that the appropriate methodological approach should be textual and content analysis.

Below is a brief description of each.

4.2.1 Textual analysis

Textual analysis approaches a text as "something we make meaning of or interpret meaning from"[169]. It could be an artefact, a book, a piece of clothing, or a graphic. In this thesis examination papers were selected as the target of the analysis.

The purpose of textual analysis is to arrive at "analytical generalisations based on carefully selected examples (…) and theoretical frameworks".[170] The selected texts must either be representative of the general population or revealing in terms of the content.

Textual analysis is utilised by "researchers to gather information about how other human beings make sense of the world".[171] It involves the act of determining approximate interpretations of texts in the quest of constructing reality. In textual analysis, "meanings are interpreted on the basis of linguistic forms that are always considered functional, that is, capable of doing things", and "semantic-syntactic interfaces that enable one to analyse action in texts".[172]

This aspect of textual analysis fits very well with the structure of Bloom's Revised Taxonomy as it places emphasis on the use of verb and noun forms which are both functional linguistic attributes that indicate the action (the verbs) to be performed within a certain dimension of knowledge (the nouns)[173].

Textual analysis is always done within a context[174]. In many cases such a context is a software programme which searches the text for pre-determined concepts. In this thesis, Bloom's

[169] McKee, 2011. *What is textual analysis*? SAGE Publications, London.

[170] Palli, P. et al. 2012. *Textual analysis.* SAGE Publications, Thousand Oaks.

[171] McKee, A. 2011. What is t*extual analysis*...2

[172] Pälli, P. et al. 2012. *Textual analysis*…3

[173] See Table 3.4

[174] Pälli, P. et al. 2012. *Textual analysis*…4

Revised Taxonomy functions as the analytical context.

4.2.2 Content Analysis

Whereas textual analysis focuses on the broader structure of a text, it is often accompanied by content analysis which focuses more on the process of *interpretation* of specific content in a text.

Content analysis is "the systematic, objective, quantitative analysis of message characteristics. It includes both human-coded analyses and computer-aided text analysis (CATA)".[175] and "is useful in describing communicative messages"[176]. "Content analysis cannot be used to draw cause-and-effect conclusions" but "can be combined with other methods to make causal claims, or the description developed through content analysis can be used as a starting point for future causal research."[177]

Content analysis can be used to analyze different types of text and "therefore is useful for studying communication from a variety of different contexts". Through content analysis, "researchers can identify trends in messages over time and subsequently explore the historical context in which the messages changed"[178]. Content analysis has experienced growth as a research technique over a period of 50+ years, from 1960 through 2014.[179]

Content analysis helps prevent two research flaws characteristic of other methodologies, namely "participant recall and recall bias"[180]. By virtue of using recorded data, content analysis "avoids the issue of misremembering"[181]. On the downside however, "content analysis cannot study what is not recorded" and can miss key "real-time" features from the communicative exchange", or "important aspects to understanding the message can be excluded".[182]

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[175] Neuendorf, K.A. 2020. *Defining content analysis*. SAGE Publications, Thousand Oaks.

[176] Maier, M.A. 2018. *Content analysis: Advantages and disadvantages.* SAGE Publications, Thousand Oaks.

[177] Maier, M.A. 2018. *Content analysis: Advantages and disadvantages…*

[178] Maier, M.A. 2018. *Content analysis: Advantages and disadvantages…*2

[179] Neuendorf, K.A. 2020. *Defining content analysis*…4

[180] Maier, M.A. 2018. *Content analysis: Advantages and disadvantages…*3

[181] Maier, M.A. 2018. *Content analysis: Advantages and disadvantages…*3

[182] Maier, M.A. 2018. *Content analysis: Advantages and disadvantages…*3-4

4.3 Construction of the Instrument of Analysis

The revised version offers an example of a framework for the development of particularised instruments – be that to design a learning module, to shape the teaching of it, or to evaluate the learning itself. Table 4.1 below shows the framework. The more colourful graphics (such as Figure 3.1) in the previous chapter are all later extensions of the original table below.

3.1 THE TAXONOMY TABLE

THE KNOWLEDGE DIMENSION	THE COGNITIVE PROCESS DIMENSION					
	1. REMEMBER	2. UNDERSTAND	3. APPLY	4. ANALYZE	5. EVALUATE	6. CREATE
A. FACTUAL KNOWLEDGE						
B. CONCEPTUAL KNOWLEDGE						
C. PROCEDURAL KNOWLEDGE						
D. META-COGNITIVE KNOWLEDGE						

Table 4.1 – Revised Bloom's taxonomy matrix[183]

[183] Anderson LW & Krathwohl DR, et al. 2001. *A Revision of Teaching, Learning and Assessing*...ii

Starting with a similar structure, the first step was to design a spreadsheet (in MS Excel) which reflects the X- and Y-axes of the above table.

The template looks as follows:

Paper Year Level		X		100	marks								
		The Cognitive Process Dimension											
The Knowledge Dimension		1		2		3		4		5		6	
		Remember		Understand		Apply		Analyse		Evaluate		Create	
D. Metacognitive Knowledge	0%		0%		0%		0%		0%		0%		0%
C. Procedural Knowledge	0%		0%		0%		0%		0%		0%		0%
B. Conceptual Knowledge	0%		0%		0%		0%		0%		0%		0%
A. Factual Knowledge	0%		0%		0%		0%		0%		0%		0%
Totals	**0%**		0%		0%		0%		0%		0%		0%
Crititcal thinking totals					**0%**		**0%**		**0%**		**0%**		**0%**

Figure 4.1 – Template for critical thinking skills coding of examination questions

A few points need to be noted:

a) In order to determine the relative presence of both the knowledge and the cognitive process factors in a paper, it is necessary to build into the template a weighting factor, which expresses each factor as a percentage of the overall maximum for the paper.
For that purpose, the template has two columns for each of the cognitive process factors. Under each cognitive process factor the first column contains the raw totals of all questions in the paper as they were allocated to a specific cross section between one factor on the X-axis and one on the Y-axis. In the second column this number is converted to a percentage of the overall maximum for the paper.
As a control factor, the total in column 2 must add up to 100% along both axes.

b) As this thesis focuses on only on that part of the taxonomy that expresses critical thinking skills a distinction inside the template is required to separate the higher order factors from the lower order factors. In the template the beige cells indicate those cross sections that were deemed to be critical thinking skills.

c) The designation of the beige coloured cross sections as being signals of critical thinking is based on the descriptors discussed in 3.4.1 and 3.4.2 in chapter 3, read and interpreted in conjunction with the overview provided in chapter 2 on the discourse regarding critical thinking and critical thinking skills.

The template errs on the liberal side insofar as cross sections are judged to be signals of critical thinking. On the basis of the literature discussed in chapters 2 and 3, it is conceivable that other investigators may exclude up to 3 cross factors from the template. This is a matter for discussion, but does not invalidate the overall tendency of the analysis.

d) The template adds a line at the bottom (in blue for easy recognition) in which the percentages of critical process thinking skills factors in each paper are given.

e) It is a question whether all instances in the template located in the beige section should be given equal weight. In favour of a form of progressive weighting is the argument that the taxonomy is inherently built on the principle of ranking. In this thesis, with the exception of one instance, this is not done. This is based on the counter argument that here are no clear perspectives in theory on which to base such a ranking (other than highly subjective preferences). The only ranking that is not unbearably subjective is along the Y-axis (moving from factual to abstract), but such a ranking is self-evident.

f) One exception to the foregoing point was made in the Apply category. In 3.4.2 (c) it was pointed out that this factor can either be understood as "executing" or "implementing". Although the template accepts both actions as reflecting critical thinking skills, it was found to be necessary to implement an element of ranking at this point. Executing is largely a repetitive action, based on a given list of prescriptions, whereas implementing requires some independent and on the spot intellectual contribution by the implementer.

To account for this difference, all incidences of Apply as being executing is given a 0.8 weighting in the template.

The significance of this point will be discussed in the next chapters.

How all of the above materialise in an assessment of a paper is illustrated in the fictitious example shown Figure 4.2 below.

In all papers the percentages were rounded off to the nearest number.

Paper Year Level		X		150	marks								
		The Cognitive Process Dimension											
The Knowledge Dimension		1		2		3		4		5		6	
		Remember		Understand		Apply		Analyse		Evaluate		Create	
D. Metacognitive Knowledge	5%	1	1%	1	1%	2	1%	3	2%	0	0%	0	0%
C. Procedural Knowledge	11%	1	1%	2	1%	2	1%	3	2%	4	3%	5	3%
B. Conceptual Knowledge	23%	10	7%	1	1%	2	1%	3	2%	4	3%	15	10%
A. Factual Knowledge	61%	20	13%	1	1%	20	13%	20	13%	20	13%	10	7%
Totals	**100%**		21%		3%		17%		19%		19%		20%
Crititcal thinking totals					**1%**		**2%**		**6%**		**19%**		**20%**

Figure 4.2 – Fictitious example of coding results

4.4 Notes about coding

It is necessary to highlight a few aspects regarding the coding procedure.

Although coding is in the first instance a result of the interpretation process as done by the reader, the revised taxonomy provides very helpful support, beyond the mere structure of the X and Y-axes. The revised taxonomy offers a list of *indicative verbs per cognitive process factor* as seen in Table 3.4. This list is a synthesis of the detailed descriptions given by Anderson and Krathwohl of the cognitive process dimensions (seen in Table 3.3). Over the years additions have been made by other users of the taxonomy. Figure 3.5 is an example. These list, based as they are on real life usage of the taxonomy, contribute greatly to refining the scope and focus of each factor in the taxonomy.

As a first approach to classifying a particular question, one, therefore, seeks to identify the operative verb in the question. This should not be done mechanically, though. Words are used differently by different people. It still remains crucial to interpret the intention of the question holistically, i.e. within the context of the paper as a whole. Even so, verb identification is a useful entry point.

Because the revised taxonomy is a matrix, the dimension of knowledge types is a very important support in determining the objection of a question. It affords a "second" take on the classification of a question. In fact, classifying the intended type of knowledge is the most important moment in determining the context of a question. In practice, the interpreter

constantly applies both dimensions simultaneously, when assessing a question.

In some cases, questions do not have any indicative verbs. This happens when, for example, a choice has to be made between options. In that case classifying the intended knowledge type, becomes the only objective criterion on which the interpreter can rely.

It must be said, however, that subjective aspects of interpretation cannot be excluded completely. In the end interpretation is the action of attaching some meaning to a text depending on the interpreter's own understanding of the written object. What the Bloom's matrix does do, is that it allows the interpreter to reference to a framework outside the interpreter's own sphere, and provides the interpreter with a means of standardised motivation for specific choices that were made in the process of interpreting.

4.5 Some examples of coded papers

The number of pages of coding that was done for this thesis runs into the hundreds. It is not feasible or useful to present all of the coded papers her (or as an appendix). On the other hand, the credibility of this thesis, and the results shown in the next chapter, rests on the actual coding.

For that reason this chapter ends with a relatively extensive extract from the coded papers. This is done so that a fair representative cross section of coding can be illustrated to allow the reader to judge the credibility of the interpretation process and the use of the taxonomy.

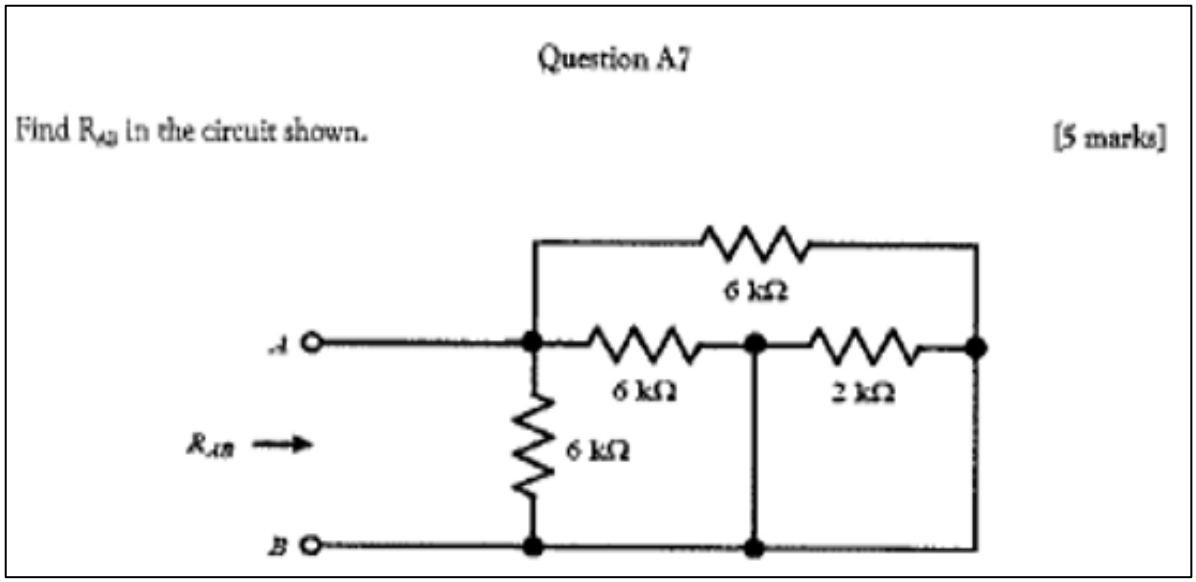
The number attached to each question indicates the location of the cross section of two factors in the taxonomy. Numbers refer to cognitive process factors (with Remember being 1) and letters refer to factors on the Y-axis

4.5.1 A detailed example

Below are two questions from the same paper.

> B5. The inner membrane of a mitochondrion has lots of folds, or cristae. Suppose that the inner membrane were smooth instead. How would this affect energy production in a cell? [3 marks]

The question above required learners to explain certain phenomena given a specific scenario. According to the taxonomy, explanation is a form of understanding. Explanation involves relating multiple elements. When the object of knowledge deals with multiple elements and their interrelationships, it is conceptual knowledge. Therefore, the question above is classified as testing *understanding* of *conceptual knowledge*. That is B2



In this question, learners were required to recall a certain procedure and apply it to finding a solution. The object of knowledge in this example is procedural knowledge as it deals with specific formulae, whilst the cognitive process action is apply. This question therefore tests application of procedural knowledge. It is classified as C3.

All other questions were classified as simple recall actions and thus assigned to A1.

The resulting classification of this examination paper is as follows:

		Remember	Understand	Apply	Analyse	Evaluate	Create
D. Metacognitive Knowledge	0%	0%	0%	0%	0%	0%	0%
C. Procedural Knowledge	37%	0%	0%	**37%**	0%	0%	0%
B. Conceptual Knowledge	51%	0%	51%	0%	0%	0%	0%
A. Factual Knowledge	12%	12%	0%	0%	0%	0%	0%
Totals	100%	12%	51%	37%	0%	0%	0%
Critical thinking skills				**30%**			

4.5.2 Examples of full paper coding

The text in red provides the reasoning behind the code assigned to each paper.

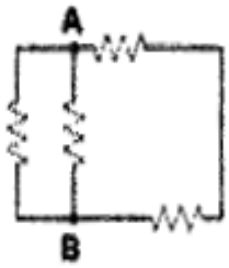
SECTION A: Answer all questions (40 marks)

Write all your answers in the exam answer booklet provided

Question A1

Calculate the resistance between A and B (R_{AB}) for the following resistor network, given that all resistors are 2.2 kΩ. [3 marks]

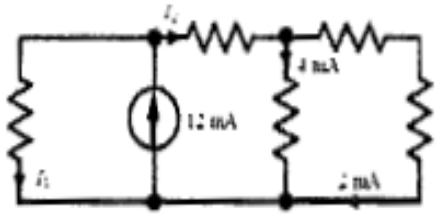
This question requires learners to apply a formula (procedure) to solve an unfamiliar problem. It is testing *application of procedural knowledge*. It is classified in cell *C3*



Question A2

Find I_1 in the network shown below: [2 marks]

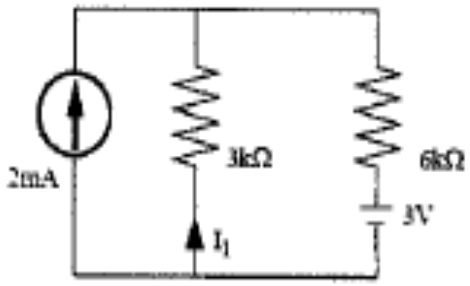
This question requires learners to apply a formula (procedure) to solve an unfamiliar problem. It is testing *application of procedural knowledge*. It is classified in cell *C3*



Question A3

Use nodal analysis to find I_1. [5 marks]

This question requires learners to apply a formula (procedure) to solve an unfamiliar problem. It is testing *application of procedural knowledge*. It is classified in cell *C3*



Question A4

Define the superposition theorem. [2 marks]

This question requires learners to recall and state facts about a particular concept. It is testing *remembering of factual knowledge*. It is classified in *A1*

Question A5

Define the maximum power transfer theorem. [2 marks]

This question requires learners to recall and state facts about a particular concept. It is testing *remembering of factual knowledge*. It is classified in *A1*

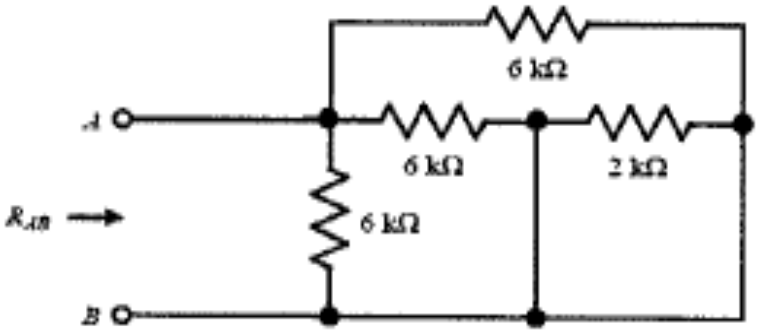
Question A6

Define kirchhoff's current law theorem. [1 mark]

This question requires learners to recall and state facts about a particular concept. It is testing *remembering of factual knowledge*. It is classified in *A1*

Question A7

Find R_{AB} in the circuit shown. [5 marks]



This question requires learners to apply a formula (procedure) to solve an unfamiliar problem. It is testing *application of procedural knowledge*. It is classified in cell *C3*

Question A8

Sketch and label a sinusoidal waveform. [4 marks]

This question requires learners to illustrate certain facts in graphical form. Illustration is a form of understanding. The question is testing *understanding of factual knowledge*. It is classified in *A2*

Question A9

Explain the term room mean square (rms) of a sinewave. [2 marks]

This questions requires learners to explain how two elements relate to each other. The question is testing *understanding of conceptual knowledge*. It is classified in *B2*

Question A10

Give ONE (1) advantage of a digital electronic system over an analogue electronic system? [2 marks]

This question requires learners to interpret the advantage of a certain element over another. The question is testing *understanding of conceptual knowledge*. It is classified in *B2*

Question A11

What is the main difference between electrical generators and motors? [4 marks]

This question requires learners to clarify the difference between two elements. The question is testing *understanding of conceptual knowledge*. It is classified in *B2*

Question A12

An alternating current completes 7 cycles in 14 ms. Determine its frequency? [2 marks]

This question requires learners to apply a formula (procedure) to solve an unfamiliar problem. It is testing *application of procedural knowledge*. It is classified in cell *C3*

Question A13

What is the difference between unidirectional and alternating a.c. waveforms? [4 marks]

This question requires learners to clarify the difference between two elements. The question is testing understanding of *conceptual knowledge*. It is classified in *B2*

Question A14

Sketch the current (I) and voltage (V) waveforms for a purely inductive a.c. circuit. [2 marks]

This question requires learners to illustrate certain facts in graphical form. Illustration is a form of understanding. The question is testing *understanding of factual knowledge*. It is classified in *A2*

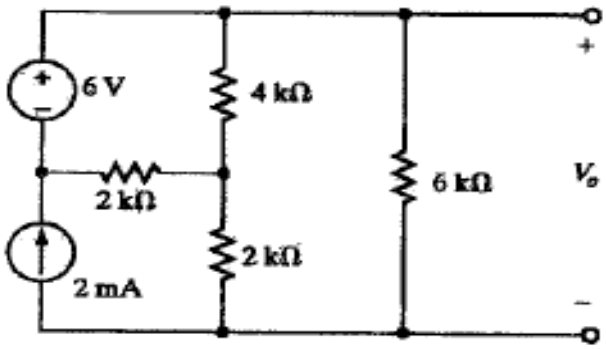
SECTION B: Choose any TWO (2) questions (20 marks)

Write all your answers in the exam answer booklet provided

Question B1

Use Thevenin's theorem to compute V_o, i.e. use 6KΩ as a load resistor [10 marks]

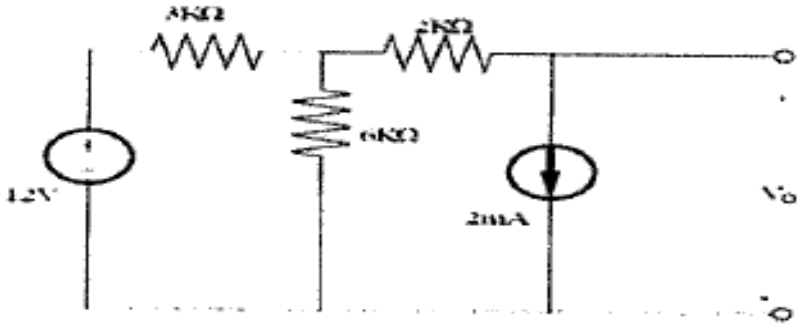
This question requires learners to apply a formula (procedure) to solve an unfamiliar problem. It is testing *application of procedural knowledge*. It is classified in cell *C3*



Question B2

This question requires learners to apply a formula (procedure) to solve an unfamiliar problem. It is testing *application of procedural knowledge*. It is classified in cell *C3*

Use loop analysis to find v_o in the network below



SECTION C: Choose any TWO (2) questions (20 marks)

Write all your answers in the exam answer booklet provided

Question C1

Describe with the aid of diagrams how three phase electricity is generated and sketch the resulting waveforms. [10 marks]

This question requires learners to represent certain elements in graphical form. Representation is a form of understanding. The question is testing *understanding* of *conceptual knowledge*. It is classified in *B2*

Question C2

Describe with the aid of diagrams the operational principles of AND & OR logic operations. [10 marks]

This question requires learners to represent certain elements in graphical form. Representation is a form of understanding. The question is testing *understanding* of *conceptual knowledge*. It is classified in *B2*

SECTION A

Answer all questions (40 marks)

1. Name the two sequencing strategies that were used in the human genome project. **(2 marks)**

This question is testing recall facts about certain elements. It is testing *remembering* of *factual knowledge*. It is classified in ***A1***

2. Give two examples of raw sequence data formats that are recognized by Bioinformatics programs. **(2 marks)**

This question is classified in *A1*. It's explanation is as in question 1 above.

3. Define the following genomics terms; contig, scaffold. **(2 marks)**

This question is classified in *A1*. It's explanation is as in question 1 above.

4. Define bridge PCR and give an example of DNA sequencing platform that uses this technique. **(3 marks)**

This question requires learners to exemplify a certain element as it relates to another element. The question is testing *understanding* of *conceptual knowledge*. It is classified in *B2*

5. Describe whole genome sequencing (WGS) and its advantages. **(3 marks)**

This question requires learners to explain a certain element and its related advantages. The question is testing *understanding* of *conceptual knowledge*. Its is classified in *B2*.

6. What is the difference between proto resistance gene and cryptic resistance gene? **(3 marks)**

This question requires learners to contrast between two elements. It is testing *understanding* of *conceptual knowledge*. Its is classified in *B2*.

7. What is de novo sequencing? Give two examples of approaches used in assembling sequences. **(3 marks)**

This question requires learners to explain a certain element and exemplify another element. Its is testing *understanding* of *conceptual knowledge*. It is classified in *B2*.

8. Differentiate between Blastn and Blastp. Explain which one is most sensitive and why? **(3 marks)**

This question requires learners to contrast two elements and explain a certain characteristic of these elements. It is testing *understanding* of *conceptual knowledge*. It is classified in *B2*.

9. Define transcriptomics and give two approaches used in transcriptomics. **(3 marks)**

This question requires learners to recall data about a certain element. Its is testing *remembering* of *factual knowledge*. It is classified in *A1*.

10. Describe emulsion PCR and give examples of 3 next generation sequencing platforms that utilizes emPCR. **(4 marks)**

This question requires learners to explain an element and exemplify other elements which utilise it. It it testing *understanding* of *conceptual knowlegde*. it is classified in *B2*.

11. Distinguish between a genomic and cDNA library, and their purposes. **(4 marks)**

This question requires learners to contrast between two elements and their applications. It is testing *understanding* of *conceptual knowledge*. It is classified in *B2*.

12. Describe derivative databases and give examples these. **(4 marks)**

This question requires learners to explain and exemplify an element. it is testing understanding of *conceptual knowledge*. It is classified in *B2*

13. What is the difference between Paired-end and Mate-pair sequencing? Give an example of next generation sequencer that utilizes each method. **(4 marks)**

This question requires learners to contrast between two elements and exemplify other elements which utilise them. It is testing *understanding* of *conceptual knowledge*. It is classified in *B2*.

Answer **ANY 4** questions)

Each question carries **25 marks**

Question 1 **[25 Marks]**

This question requires learners to offer an explanation of two elements, how they differ and their application within the wider concept. The question is testing *understanding of conceptual knowledge*. It is classified in *B2*.

(a) Distinguish between Micro-Economics and Macro-Economics with their applications **(8 Marks)**

This question requires learners to recall and state facts about a certain element and represent it in graphical form. It is testing *remembering of factual knowledge*. It is classified in *A1*

(b) Define **Break-Even Point** (BEP) and draw a fully labelled BEP chart. **(9 Marks)**

(c) State and describe any **four** risk management strategies? **(8 Marks)**

This question requires that learners explain certain elements of a concept. Explanation is a form of understanding. The question is testing *understating of conceptual knowledge*. It is classified in *B2*.

Question 2 This question requires that learners explain certain elements of a concept. Explanation is a form of understanding. The question is testing *understating of conceptual knowledge*. It is classified in *B2*. **[25 Marks]**

(a) Mention and discuss **five** factors that influence competition in a market. **(10 Marks)**

(b) List and explain briefly the **five** types of legal organization formations **(10 Marks)**

This question is classified in *B2*. Its explanation is as in question (a) above.

(c) State and describe **two** general categories of business risks. **(5 Marks)**

This question is classified in *B2*. Its explanation is as in question (a) above.

Question 3 **[25 Marks]**

(a) What are the **three** stages of risk management? **(3 Marks)**

This question requires learners to recall and state facts about a certain element. It is testing *remembering of factual knowledge*. It is classified in *A1*

(b) Tutume Investment Ltd's cost of capital is **13%** and it is considering a capital investment project, where the estimated cash flows are as follows:

Year	Cash flow (Pula)
0 (i.e., now)	(430,000)
1	240,000
2	320,000
3	160,000
4	120,000

Calculate the **NPV** of the project and give an evaluated decision whether it should be undertake? **(7 Marks)**

This question requires that learners apply a learnt procedure (formula) to solve an unfamiliar problem. It is testing *application of procedural knowledge*. It is classified in *C3*

(c) In a particular village, the vehicle users take a roundabout route to reach certain places because of the presence of a river. This results in excessive travel time and increased fuel cost. So, the District Council is planning to construct a bridge across the river. The estimated initial investment for constructing the bridge is P 4,000,000. The estimated life of the bridge is 15 years. The annual operation and maintenance cost is P 150,000. The value of fuel savings due to the construction of the bridge is P 600,000 in the first year and it increases by P 50,000 every year thereafter till the end of the life of the bridge. Check whether the project is justified based on **Benefit-Cost ratio** by assuming an interest rate of 12%, compounded annually.

(15 Marks)

This question requires that learners apply a learnt procedure (formula) to solve an unfamiliar problem. It is testing *application of procedural knowledge*. It is classified in *C3*

Question 4 **[25 Marks]**

(a) In a tabular form compare the characteristics of the market structures of the following
(i) Competitive markets
(ii) Monopolies
(iii) Oligopolies

(6 Marks)

This question requires that learners explain and contrast the characteristics of certain elements. Explanation and contrasting are a form of understanding. The question is testing *understanding of conceptual knowledge*. It is classified in *B2*.

(b) Briefly discuss **two** ways how a business can mitigate against the risk of fire.

(4 Marks)

This question requires that learners explain certain elements of a concept. Its is testing *understanding of conceptual knowledge*. It is classified in *B2*.

(c) Looking at the figures in the table below for two mutually exclusive industrial power station installation projects. Projects A and B both have an initial capital cost or investment of P238, 000 but they have varied capital cost of asset profit depreciation values over a 5 year period (thus, only one of them can gain project financing – which one does your evaluation pick?). Calculate the **Pay-back period** for the two projects.

(15 Marks)

Capital cost of asset Profit before depreciation	Project - A (Pula) P 238,000	Project - B (Pula) P 238,000
Year 1	90,000	133,000
Year 2	20,000	70,000
Year 3	70,000	30,000
Year 4	58,000	13,000
Year 5	230,000	15,000

This question requires that learners apply a learnt procedure (formula) to solve an unfamiliar problem. It is testing *application of procedural knowledge*. It is classified in *C3*

4.6 Conclusion

This chapter explained the methodological considerations behind the instrument of analysis, as well as the details of the actual construction and application of it. The combination of textual

and content analysis with the two-dimensional framework that the revised version of Bloom's taxonomy provides, offers an opportunity for a more granular analysis which departs from the uni-dimensional analyses of the earlier taxonomy.

In the next chapter the findings of the analysis of exam papers will be presented.

Chapter 5

Critical thinking skills in examination papers

5.1 Introduction

This chapter presents the data which was generated by the application of the instrument of analysis to the selected examination papers.

In all 64[184] different examination papers were analysed. All of them were year-end papers covering the academic years from 2015 to 2019

Of these papers:

- 32 were in engineering,
- 18 in the sciences and
- 14 in complementary subjects that include statistics and business fields.

53 of the papers are from 1st to 3rd year, i.e. at undergraduate level.

At levels 4, 5, and 6 only a total of 11 were published. The most likely reason is that most of

[184] More than the papers analysed in this thesis are available online, but they are copies of previous papers. The duplicates have been filtered out, leaving the 64 discussed here.

the programmes in the institution started running only in the 2012/2013 academic year[185] and only released the first graduates in the 2016/2017 academic year[186].

It is important to underline once again that the aim of this thesis is *not* to educationally evaluate the papers. The objective of the analysis is a holistic profile of the actual presence and types of critical thinking as displayed in the examination practices.

The fact that the papers are spread over a number of years, as well as over a wide range of subjects, supports the objective of a holistic evaluation. It allows for a profiling that is more credible in aggregate, and perhaps more generalisable institutionally, than a focus on one subject or programme would have been.

Consequently, the coding was done by paper (as illustrated in the previous chapter) but was then aggregated into groups. Seeing that the exam papers, in this case, have a basic homogeneity (in that the university as such is focused on science and technology) it made sense to group papers according to academic levels, rather than subjects. However, as there are only 11 papers for levels 4, 5 and 6 it was decided to group them together based on the assumption that they all operate at post-graduate level.

This means that the papers are divided into 4. groups There are 12 papers at first year level, 20 at second, 21 at third, and 11 at post-graduate levels.

In the next section below, the data will be presented in 3 charts for each of the of the 4 levels., as follows:

- The first chart extracts from the Excel data a picture of the spread across the 4 knowledge types.
- The second chart does the same for the spread across the 6 cognitive processes.
- The third chart offers a 3D view of the combined picture per level. In this view the reduction of component C3 (by multiplying it with 0.8) as explained in the previous chapter, is visible.

A summary discussion follows at the end of each level.

[185] www.biust.ac.bw

[186] Daily News newspaper. The article reported the first graduation of BIUST students since the university opened in 2012.

5.2 Presentations of data per academic level

5.2.1 First year level: knowledge types

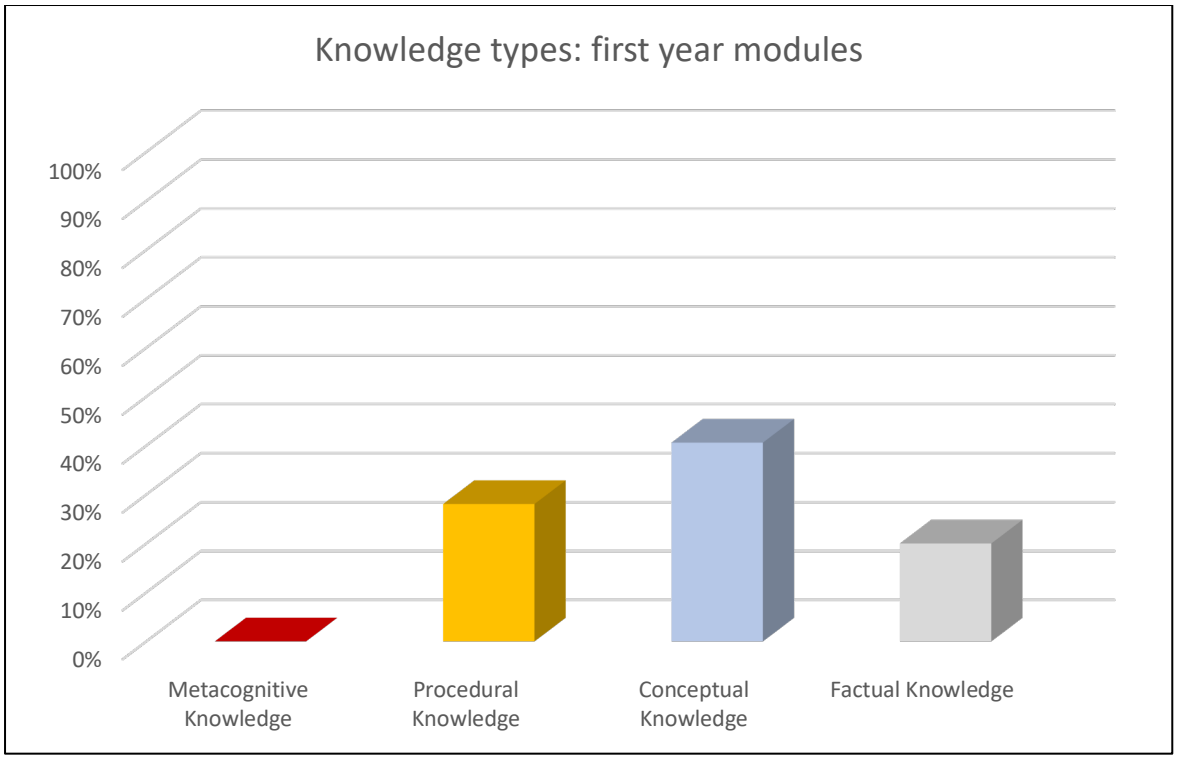


Figure 5.1 – Knowledge types: all first year modules

5.2.2 First year level: cognitive processes

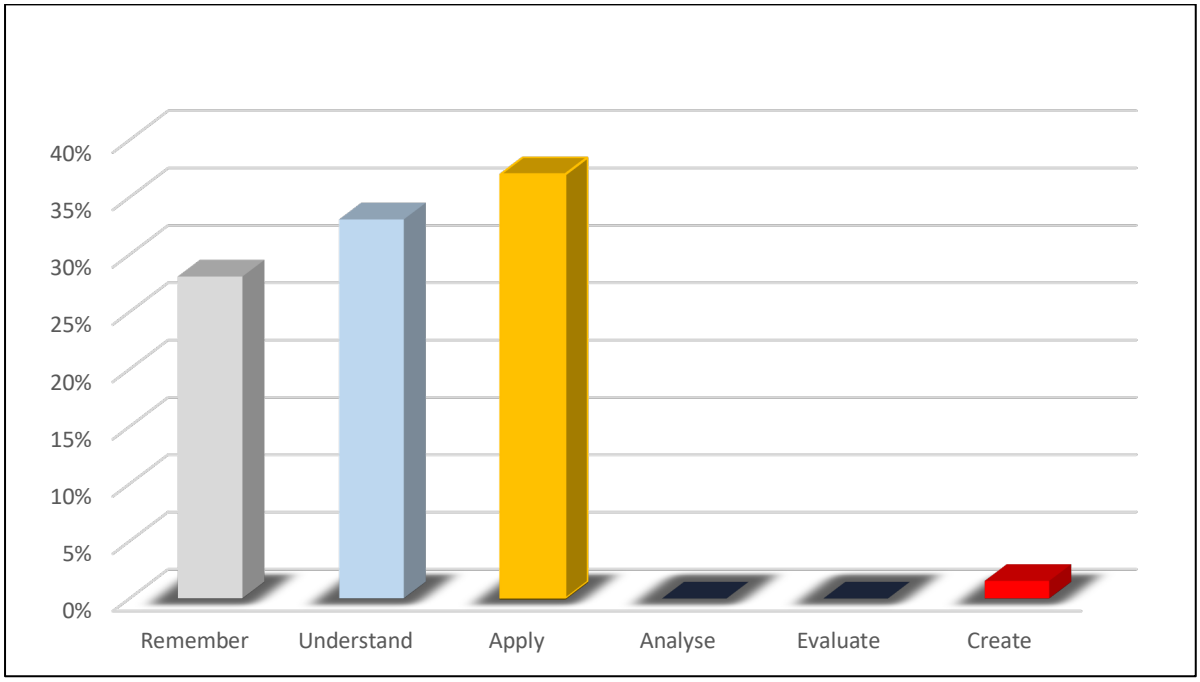


Figure 5.2 – Cognitive process: all first year modules

5.2.3 First year level: combined profile

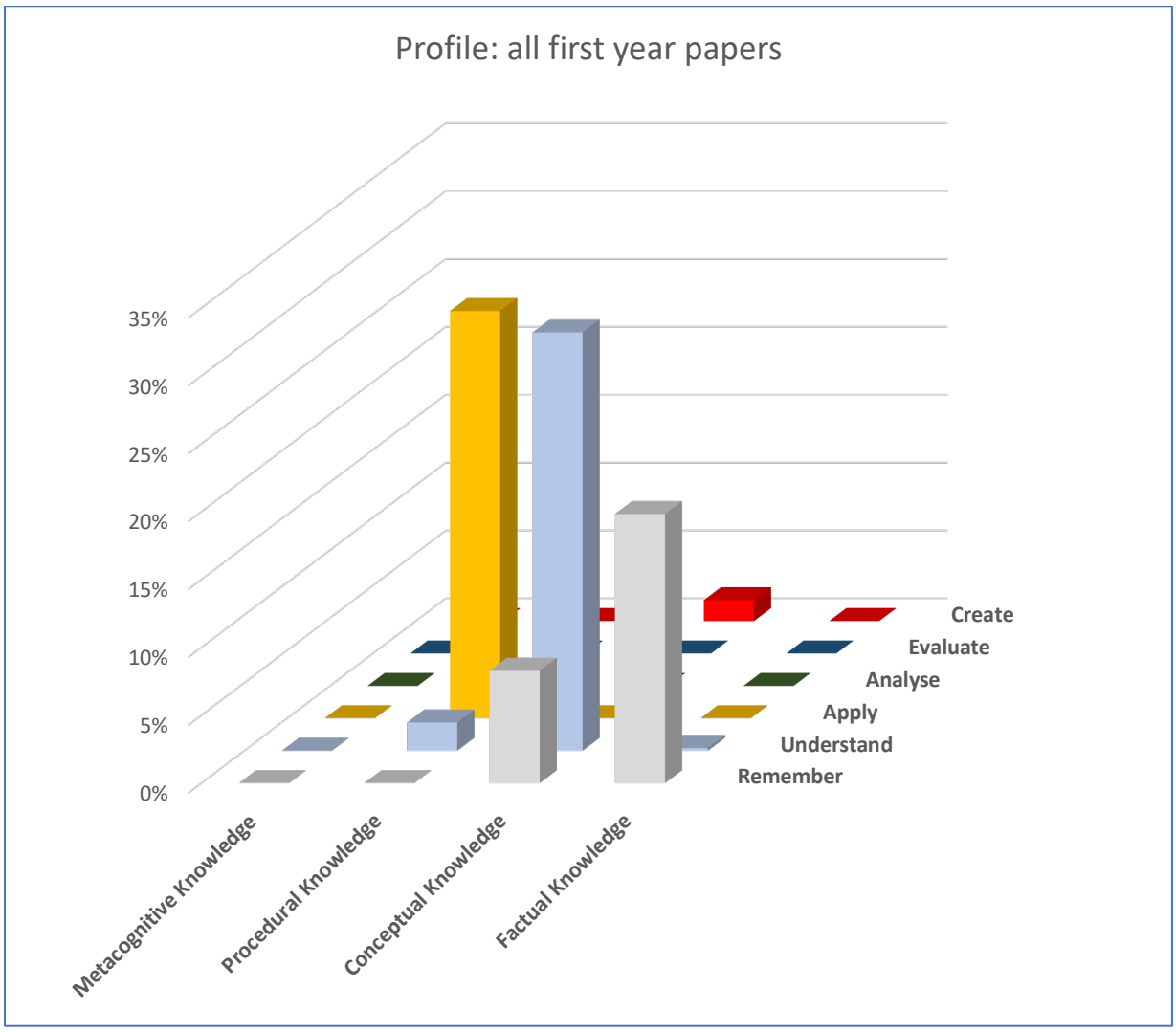


Figure 5.3 – Overall profile of first year papers

5.2.4 First year level discussion

The concentration on remember and understand is clear from the graphics.

In the combined chart it can be seen that only 2% of questions fall in the interval of create and conceptual knowledge. With 26% of questions falling in the interval of procedural knowledge and apply. In fact the concentration on C3 is quite notable.

In the first year modules the emphasis is clearly on conceptual and procedural knowledge with respectively 41% and 38%. The rest is made up of factual knowledge.

5.3 Analysis of second year papers

5.3.1 Second year level: knowledge types

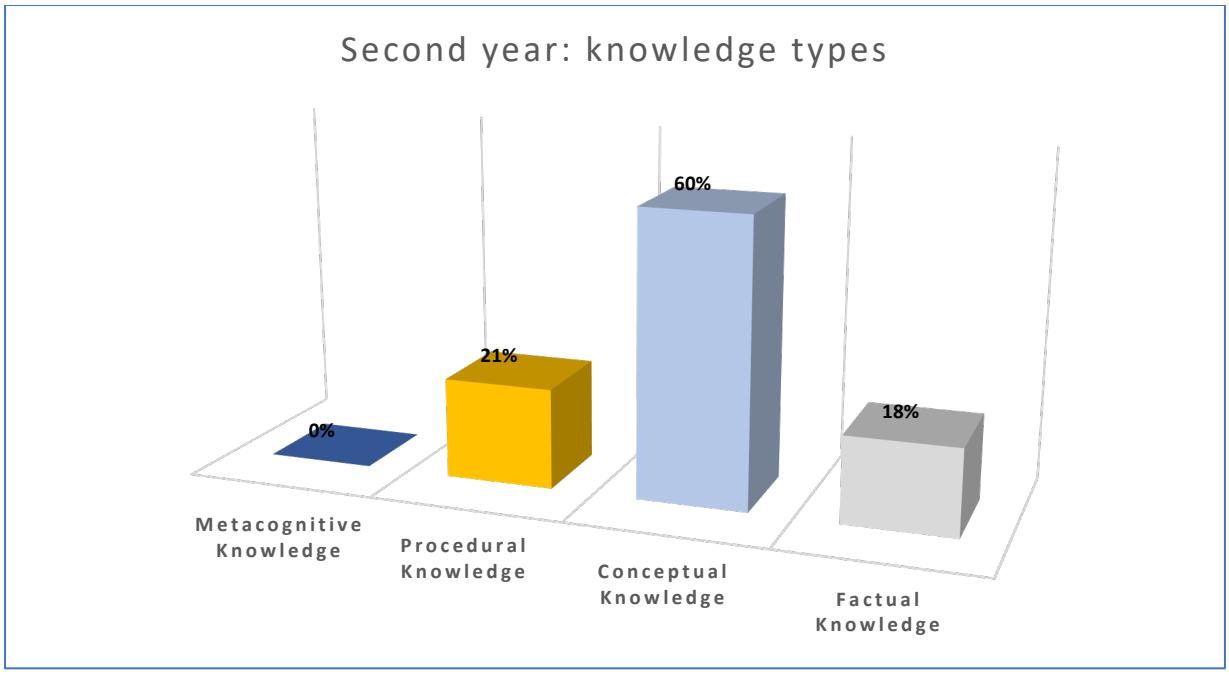


Figure 5.4 – Second year knowledge types

5.3.2 Second year level: cognitive processes

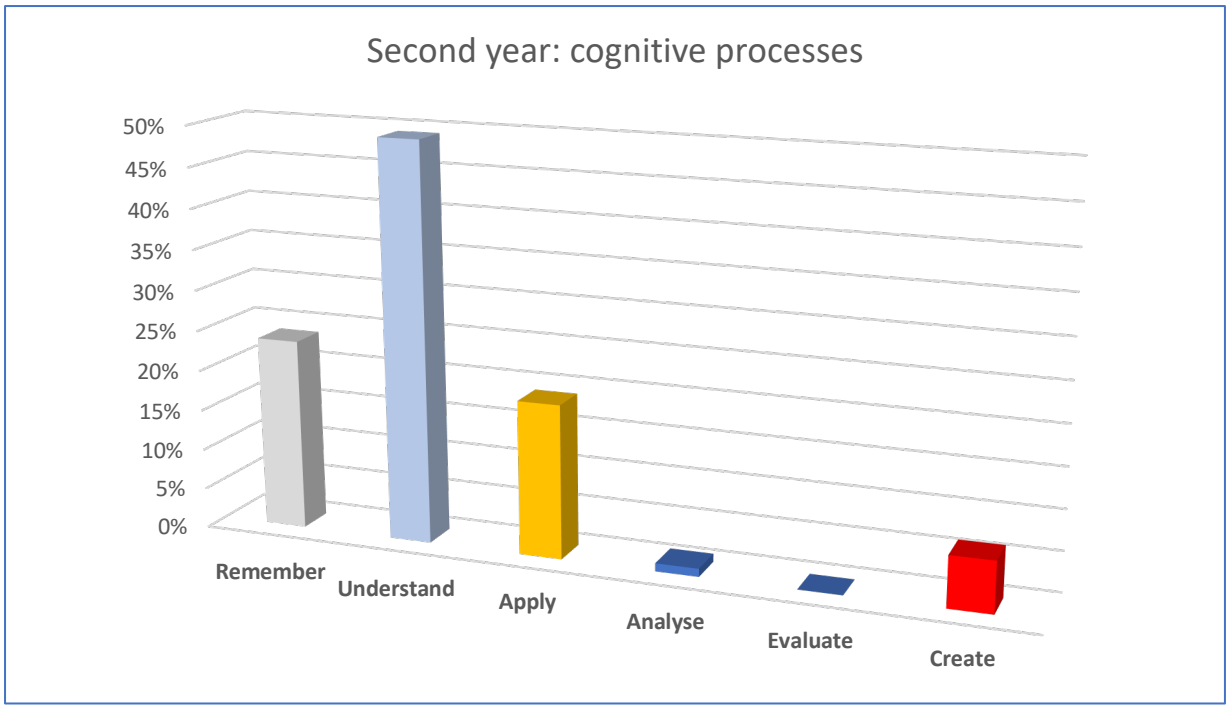


Figure 5.5 – Second year cognitive processes

5.3.3 Second year level: combined profile

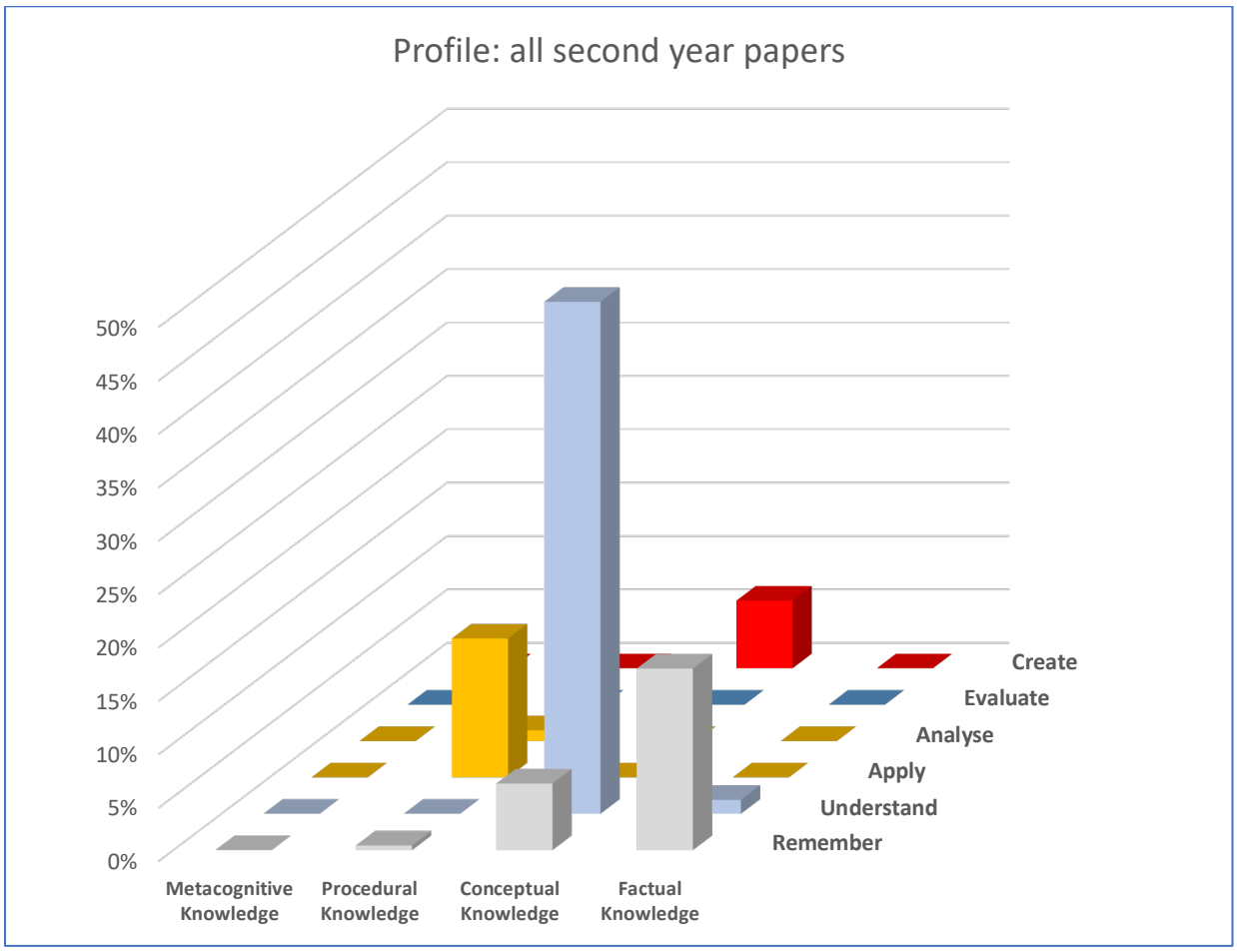


Figure 5.6 – Overall profile of all second year papers

5.3.4 Second year level discussion

In the second year the outstanding feature is the emphasis on conceptual knowledge. 48% of weighted paper content falls in this category.

By contrast with the first year, only 13% is in the categories of procedural and apply.

In the cognitive process category of create 6% can be observed. This is significantly higher than in the first year, although (like the first year) the skill is confined the creation of conceptual knowledge.

Overall the grouping of components of the matrix looks similar to the first year.

5.4 Analysis of third year papers

5.4.1 Third year level: knowledge types

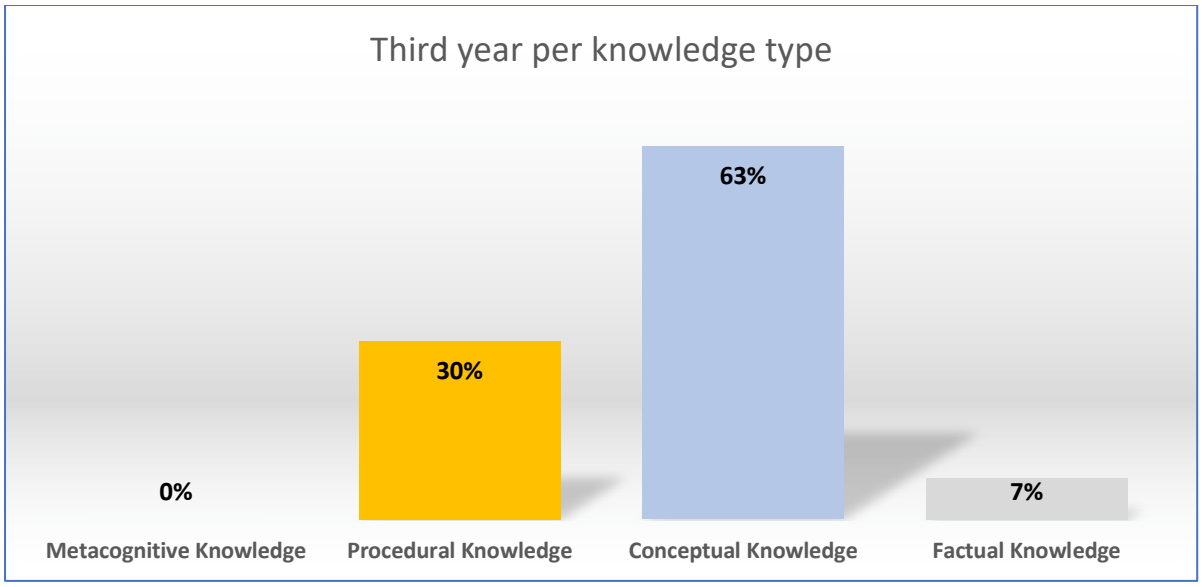


Figure 5.7 – Third year knowledge types

5.4.2 Third year level: cognitive processes

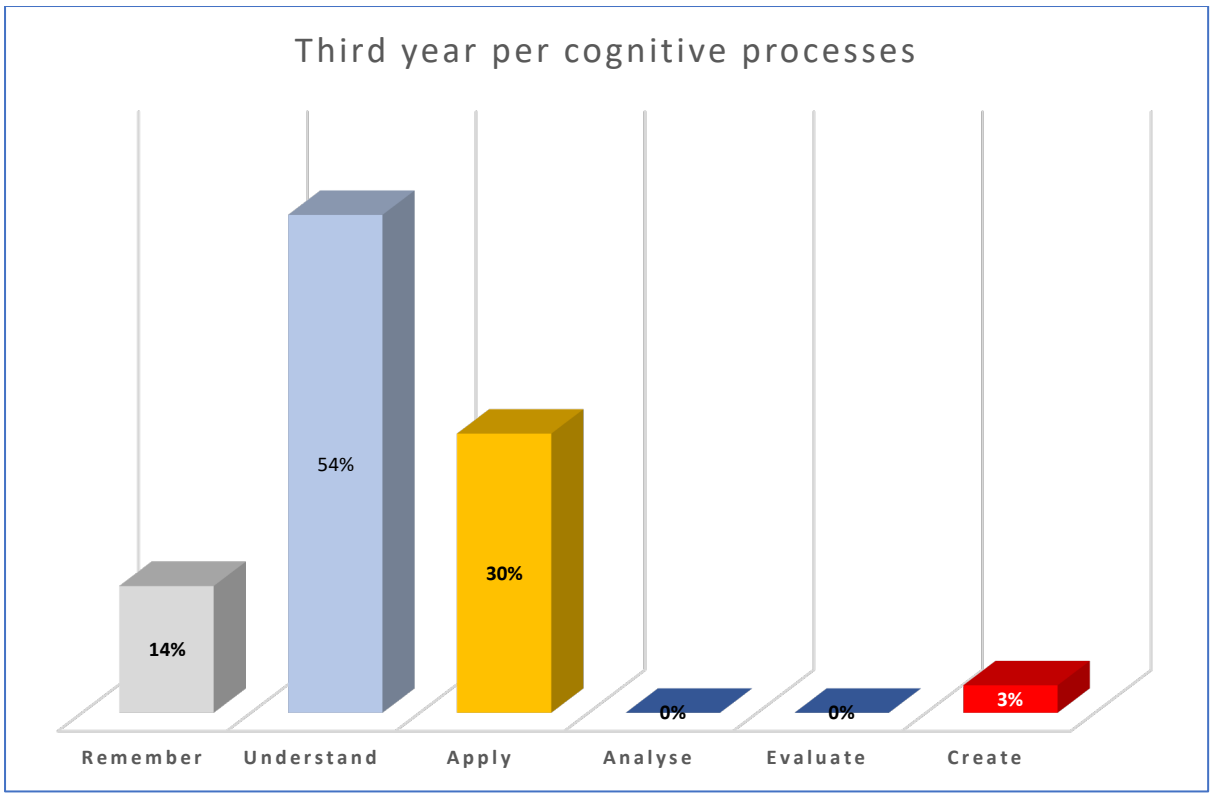


Figure 5.8 – Third year cognitive processes

5.4.3 Third year level: combined profile

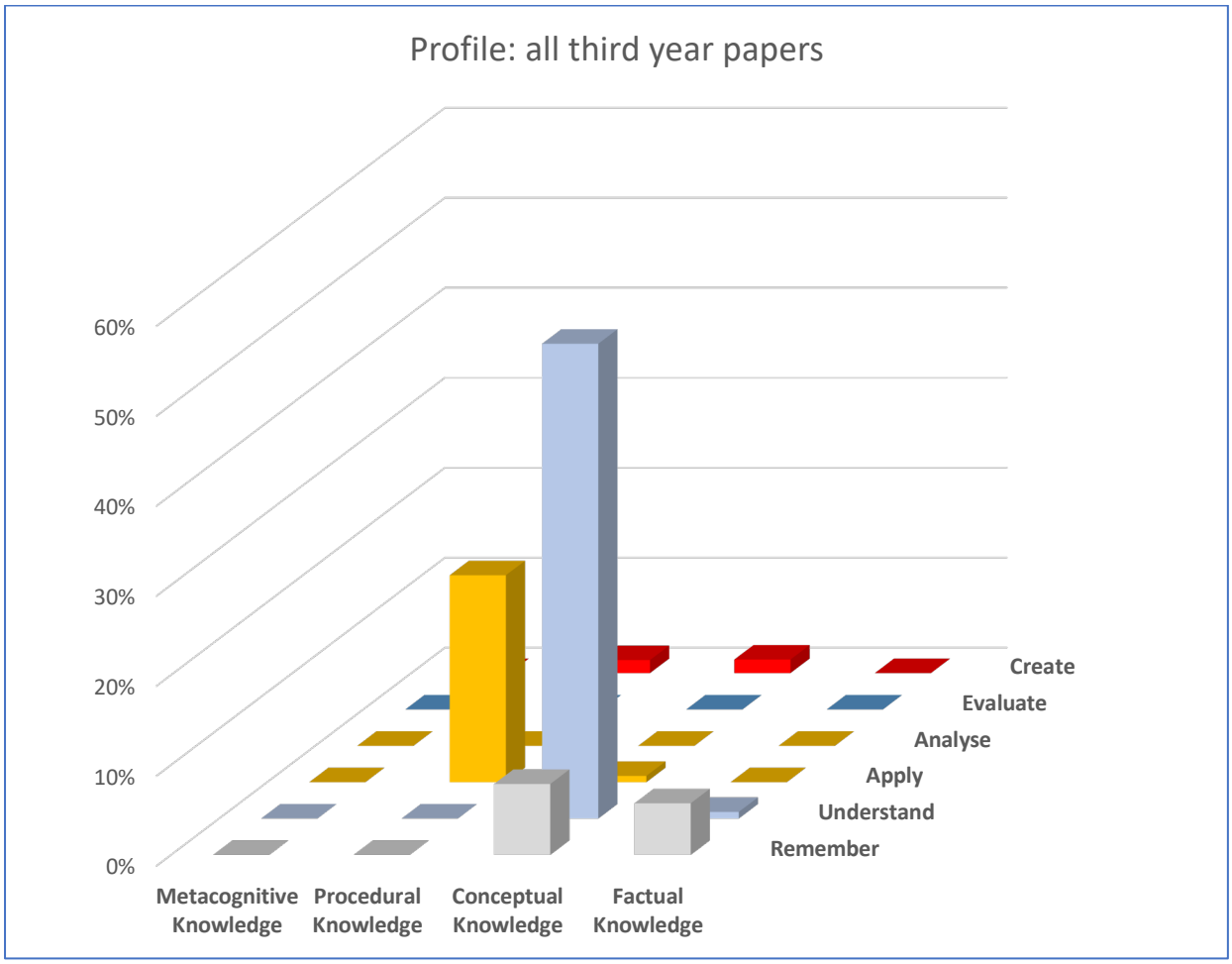


Figure 5.9 – Overall profile of all third year papers

5.4.4 Third year level discussion

Understanding conceptual knowledge scores even more in the third year compared to the second. Conceptual understanding scores 53%, whereas the conceptual knowledge type as a whole scores 63%

Procedural application is 30% which is considerably higher than in the second year.

There is diversification in the category of create. The overall score of 3% is lower but creation of procedures is added to creation of conceptual knowledge.

5.5 Analysis of post-graduate papers

5.5.1 Post-graduate level: knowledge types

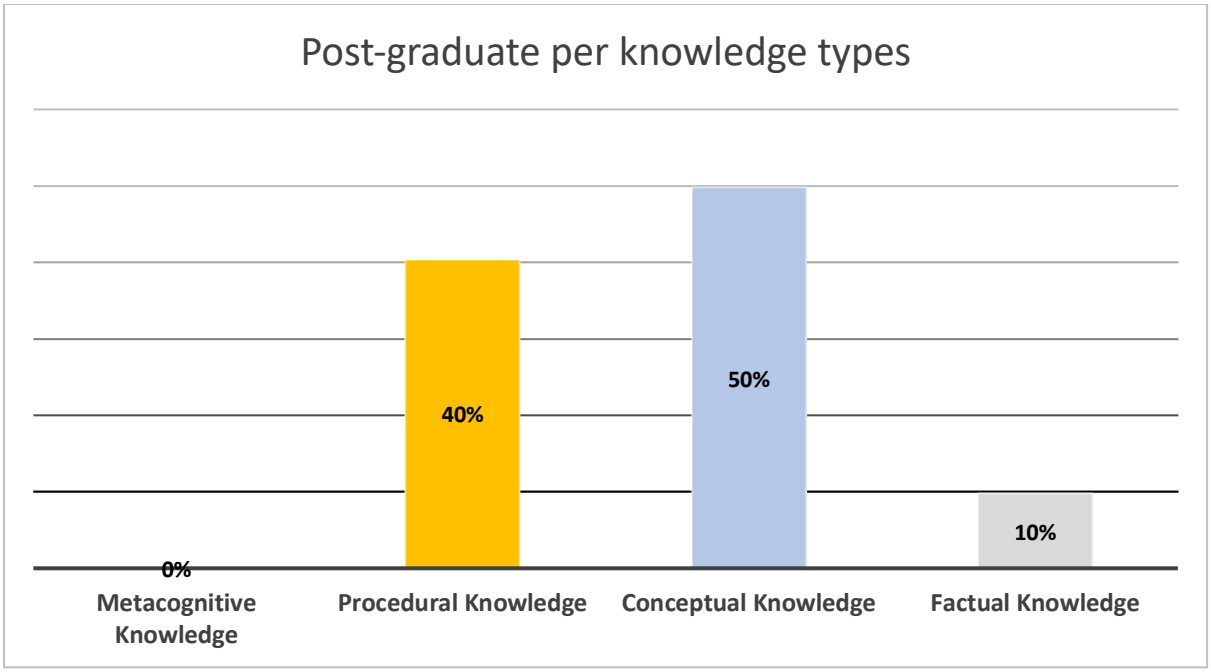


Figure 5.10 – Post-graduate knowledge types

5.5.2 Post-graduate level: cognitive process

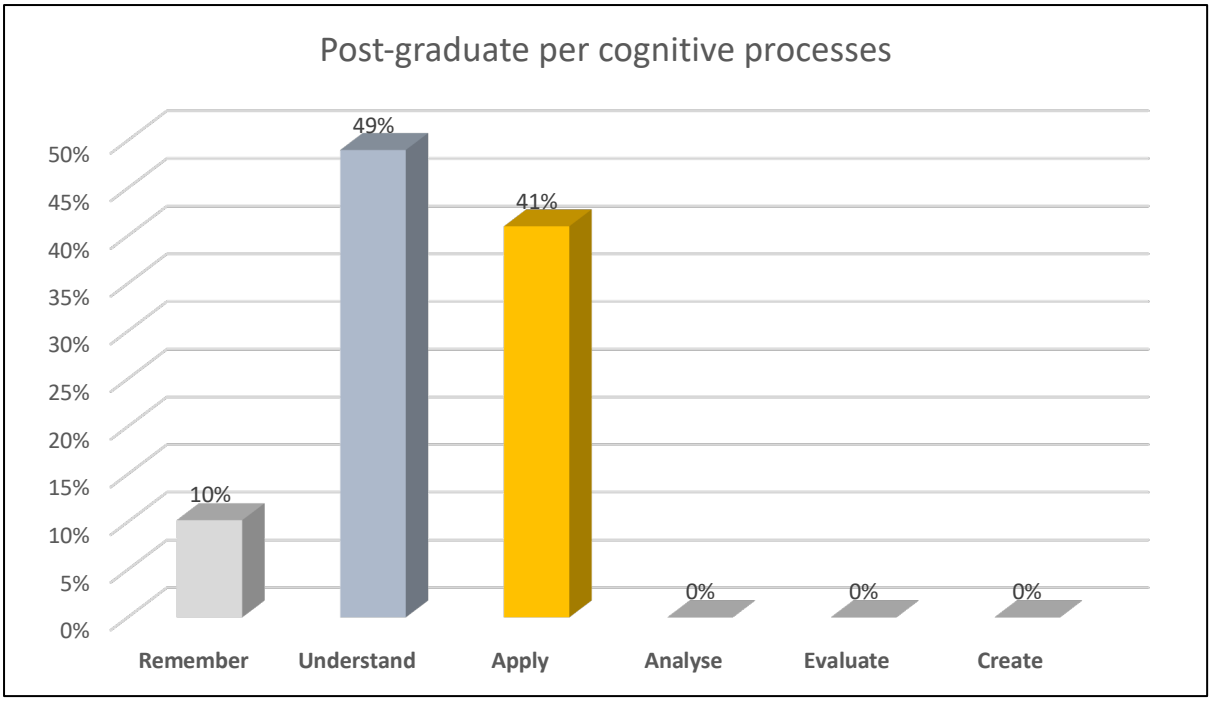


Figure 5.11 – Post-graduate cognitive processes

5.5.3 Post-graduate level: combined profile

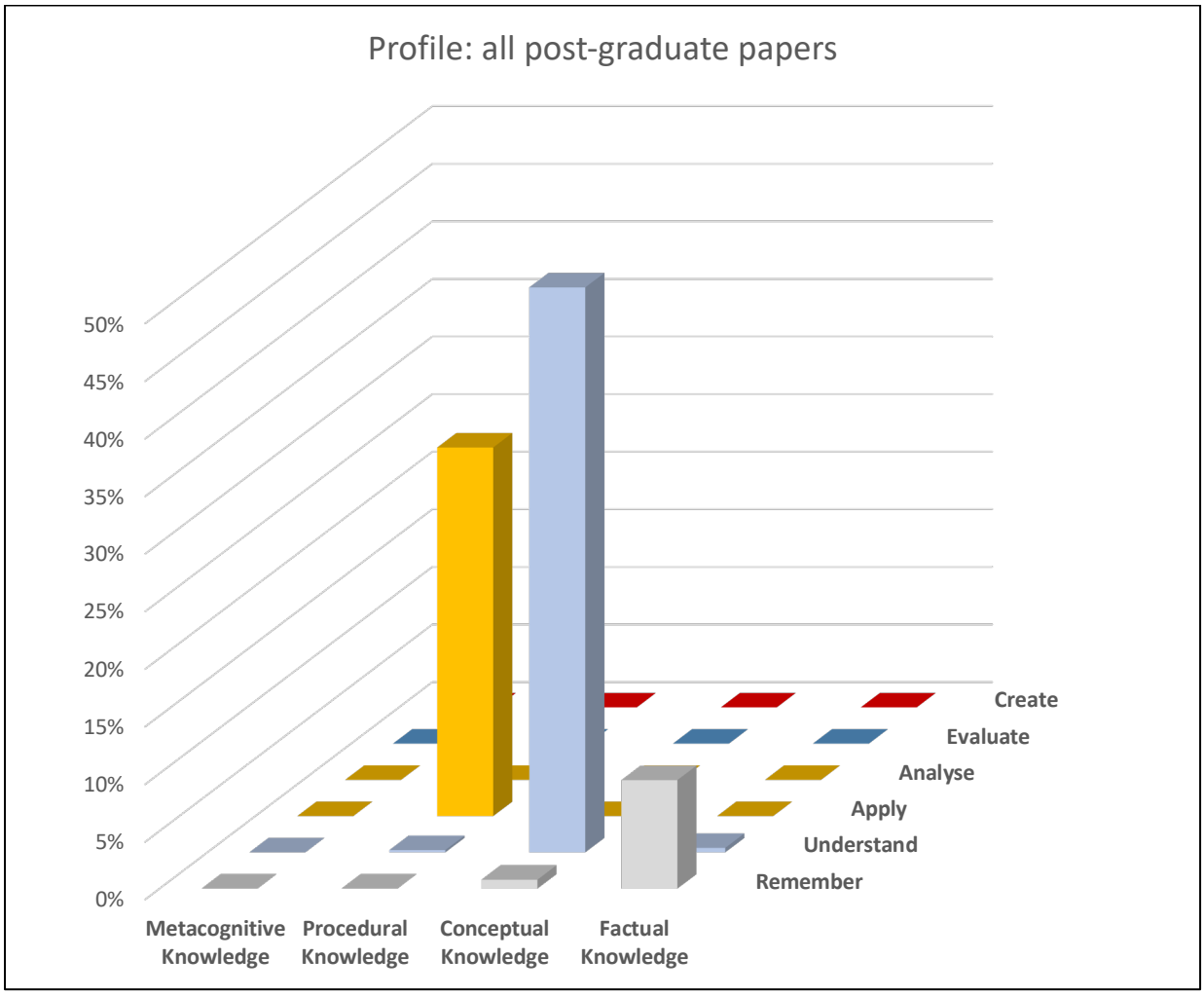


Figure 5.12 – Overall profile of all post-graduate papers

5.5.4 Post-graduate level discussion

As can be expected understanding of conceptual knowledge is the most prominent component with 50%.

This is closely followed by procedural application with 40%

Pure recall of factual knowledge scores 10%.

What is surprising is the absence of any of the higher order skills of analysis, evaluation and creation.

5.6 Analysis of Apply and Create

In the analysis presented above only two of the knowledge processes associated with critical thinking skills have been identified. These are the skills of Apply and Create.

In this section an analysis of each of the two are presented.

5.6.1 Procedural knowledge and Apply

In 3.4.2(c) and Table 3.4 the distinction between the cognitive skill of applying as being *executing* as opposed to *implementing* was discussed. The distinction between the two activities corelate with whether the procedure is a familiar one or not. If it is a familiar one, Apply consists of repetition of a known set of actions. If it is an unfamiliar procedure the nature of Apply changes from repetition to developing a new understanding of the required process as well as an appropriate method.

It is clear that executing largely rests on remembering previous actions or a set procedure which is commonly used. On the other hand, implementing tends in the direction of Create. At the very least, understanding of relevant conceptual knowledge is required. Even then, the ability to turn understanding into the appropriate procedure must be demonstrated. As such, Apply, when in the mode of implementing, can be considered a truly critical thinking skill. In the mode of executing, however, it is on the borderline between lower and higher order thinking skills.

The graphs below show the following results:

- 47 out of the total number of 64 papers, included questions that required procedural knowledge and the skill of application
- The general profile is one of a high concentration on the application of procedural knowledge across all papers
- Of the papers in this category 53% of all questions at levels 4, 5 and 6 focus on the application of procedural knowledge
- At 3rd year level, the percentage of questions devoted to Apply is 52%, in the 2nd year it is 29% and in the 1st year it is 42%
- However, it must be noted that no instance could be found of a question that demanded implementation. As the graphs demonstrate, all questions in this category anticipated answers that are classified in the Bloom's taxonomy as being execution

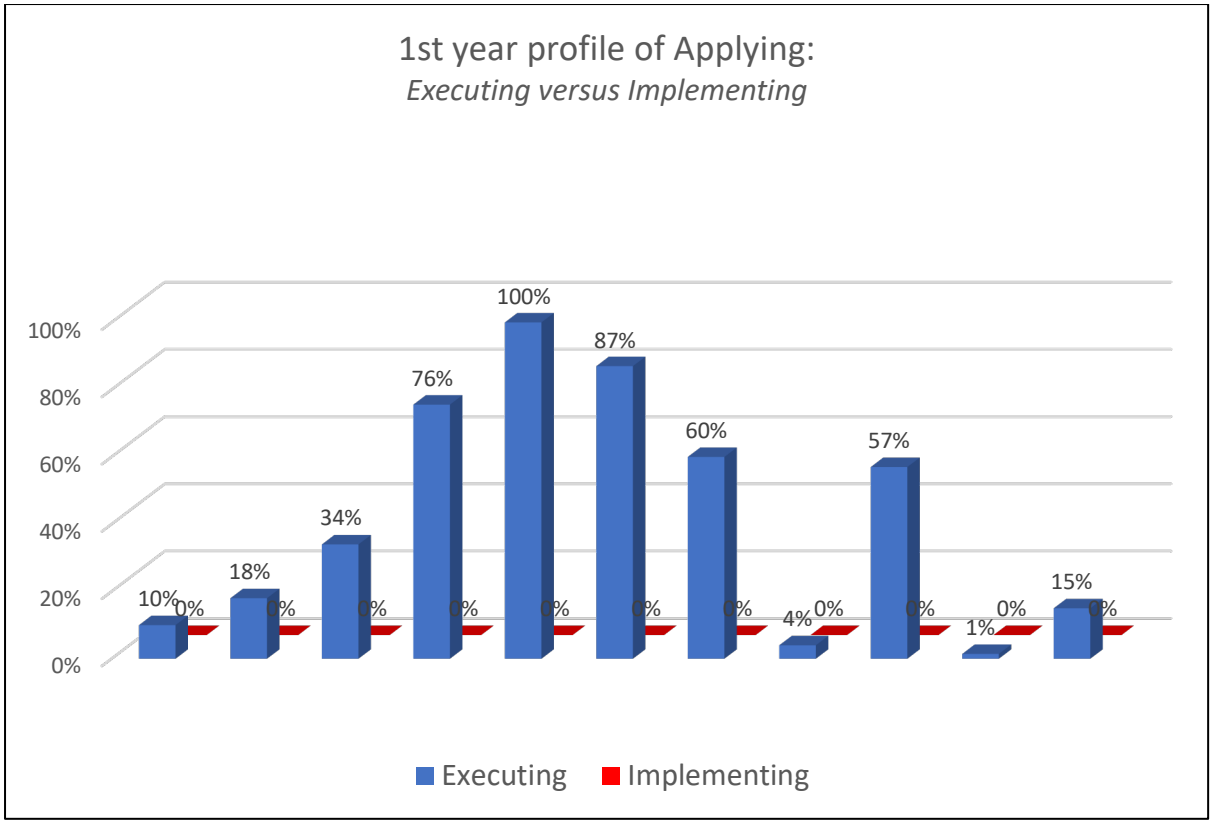


Figure 5.13 – Executing versus implementing: 1st year papers

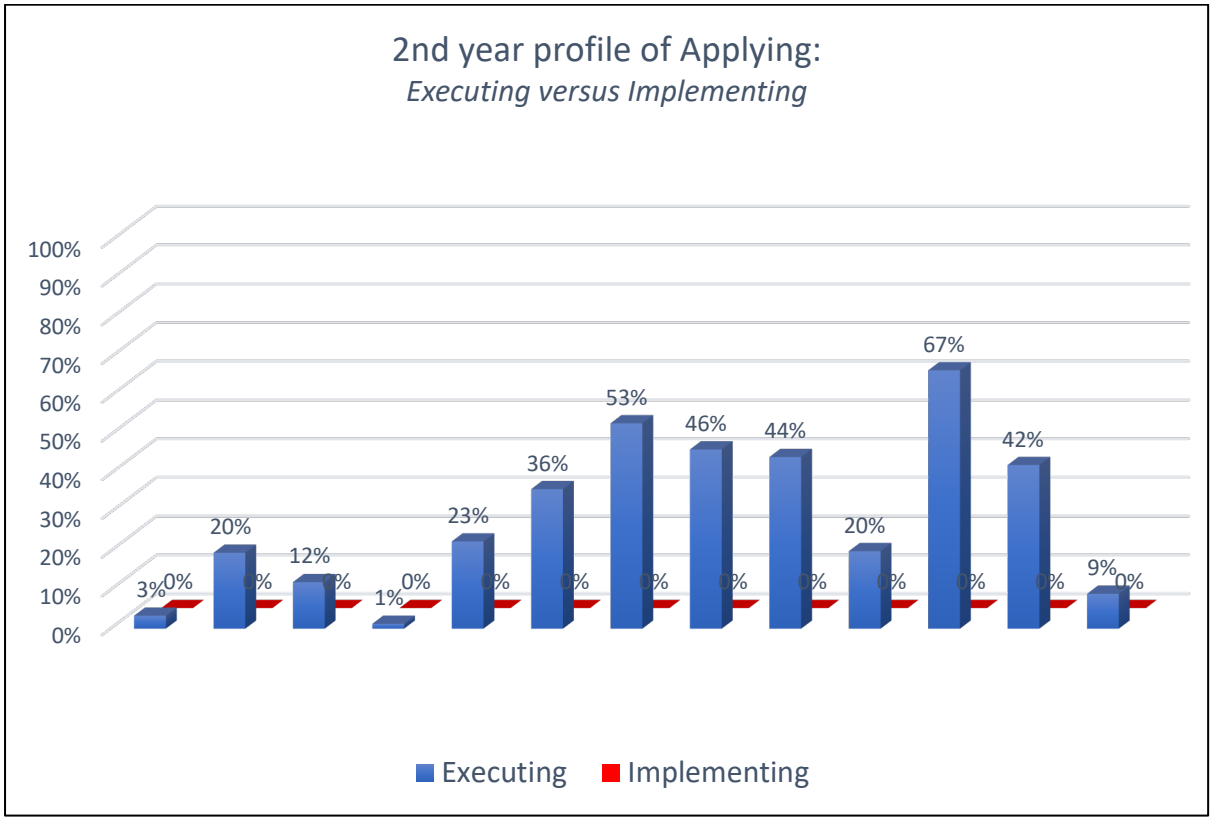


Figure 5.14 – Executing versus implementing: 2nd year papers

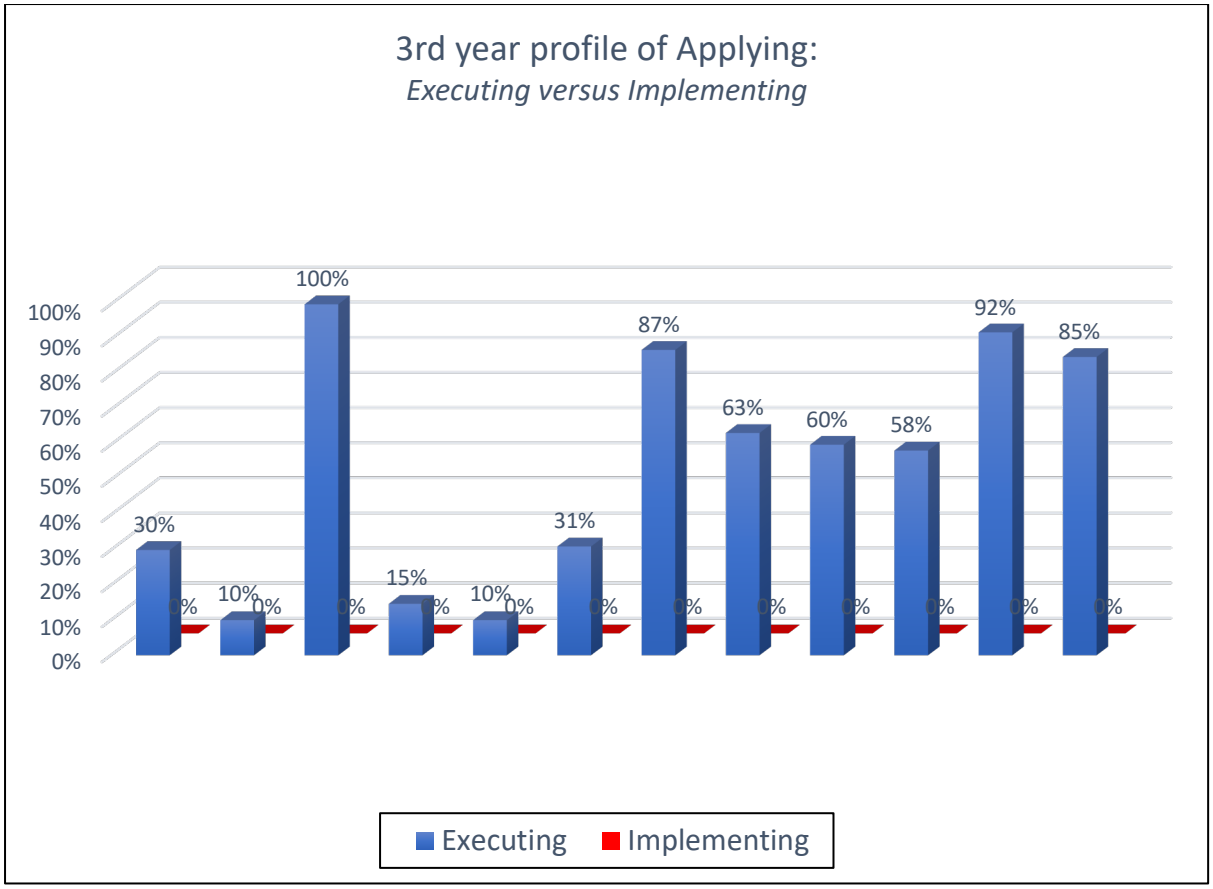


Figure 5.15 – Executing versus implementing: 3rd year papers

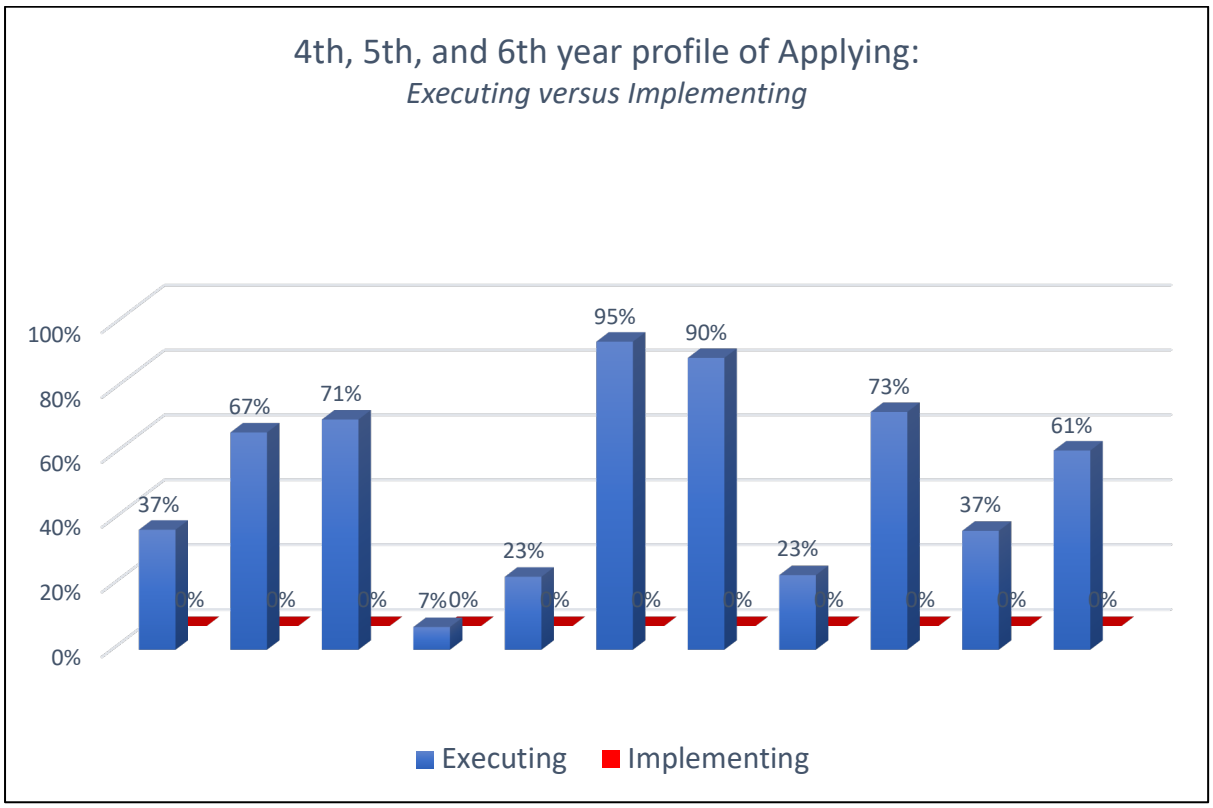


Figure 5.16 – Executing versus implementing: post-graduate papers

5.6.2 The process dimension of Create

In contrast to Apply, only a total of 7 out of 64 papers yielded a score in the Create category. This means that only 11% of all papers contained questions at the highest level of thinking skills.

It must be noted that no paper in the group of 4th, 5th or 6th years included any question that fits this category. This means that all 7 papers in the Create category came from the 53 under-graduate papers.

The process dimension of Create comprises of three distinct actions: generating, planning and producing. For a question to fall into the Create category, at the very least there has to be a requirement to generate a concept with an eye on turning the concept into some form of practice. In 5 of the papers the questions required the student to develop the generated concept up to production. In these cases, the intended product was conceptual in nature. In the remaining two cases the ultimate objective was such that it could not materialise in a theoretical examination setting. Therefore, only partial demonstrations of the components of Create are requested.

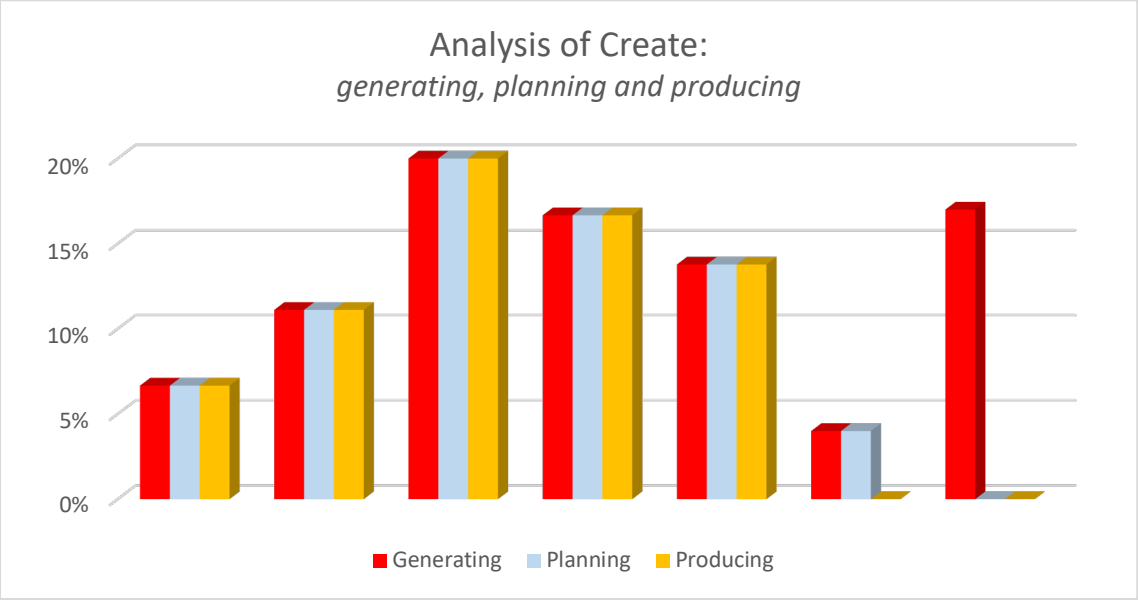


Figure 5.17 – Generating, planning and producing

5.7 Conclusion

In this chapter the data generated by the application of the Bloom's taxonomy based instrument of analysis to 64 year end examination papers was presented.

In the next chapter some implications of the presented data will be discussed.

Chapter 6

Evaluation and conclusions

6.1 The thesis in a nutshell

The starting point of the research that was done for this thesis was the assumption that critical thinking, and critical thinking skills is a necessary component of business and societal life in our time. This is so in particular as the importance of knowledge in economic life is growing.

As was noted in chapter 1, for some time already an unease is felt in Botswana with regard to the efficiency of the education system to deliver the more advanced skills that the growing industrialisation of Botswana needs. Added to that, the country now aims to move up the production value chain toward the so-called 4th industrial revolution, and that requires more advanced knowledge skills than in the past. All of this points toward an interest in critical thinking skills development. To deliver these, all eyes are on the tertiary education sector.

Against this backdrop, this thesis is the outcome of a research project designed to try to determine *to what extent and in what format the development of critical thinking can be detected in the tertiary education system in Botswana.* Confined by the scope of a master's thesis as well as by feasibility, this question had to be narrowed down to a probe in one tertiary institution of year-end examination papers. On the assumption that year-end examination papers can be accepted as a proxy for the overall objectives of a course, an instrument of analysis, based on the revised version of Bloom's taxonomy, was developed and applied.

In the previous chapter the results of the analysis were given. In this chapter a number of conclusions drawn from the results will be offered.

6.2 Profile of the results per academic level

Before going on to general evaluations and conclusions, a profile of the most prominent features of the results will be drawn for each academic level.

a) Undergraduate level

The following observations can be made on the basis of the aggregated data results for undergraduate papers:

Firstly, a gradual decline from first to third year of questions targeting *memorising* of facts or concepts is observable. This is very much in line with expectations at undergraduate levels.

Secondly, the factor of *application* of procedures (C3) dominates the first year, but in subsequent years is drastically lower. This is surprising. An increase rather than a decrease would have been expected. Without interrogating the papers in curricular detail (which is beyond the reach and competency of this study), an explanation is not possible. Instead, it can only be speculated that the high level of application in the first year, results from an emphasis on training students to execute specific, prescribed routines. If this interpretation is correct, application cannot, in this case, be seen as higher order thinking, but simply as a memorising by way of the practice of routines. This interpretation is supported by the lower levels of this particular factor in all subsequent years.

Thirdly, in the second and third years *understanding* of concepts (B2) dominate. This is in and of itself not remarkable, except for the sharp contrast to the first year configuration. Altogether, though, the second and third years seem to be more balanced.

Fourthly, at all three levels there are instances of the highest level, that is of the skill of *create*. Surprisingly, no evidence of evaluate or analysis was found. Also not as expected is the fact that there is no gradual increase in the weight of the skill of create from first to third year, or introduction of evaluate and analyse at higher levels.

b) Postgraduate level

Two aspects stand out with regard to the postgraduate papers:

Firstly, there is a *complete absence of any of the higher order skills* of analysis, evaluation, and create. The only category that is considered to be part of higher order skills (in this thesis) is the skill of apply. However, this can only be accepted as a marginal version of

critical thinking, as will be argued in 6.3 below. Given the fact that at least the skill of create could be identified in undergraduate papers, it is puzzling why none of the 11 postgraduate papers yielded such a coding result.

Secondly, a very clear concentration on *understanding* of conceptual knowledge is seen. At the same time the weight of procedural application is clearly higher than in the second and third years of undergraduate papers. These two factors together (i.e. B2 and C3) delivers a significantly higher total of 90% of all (weighted) questions, compared to the undergraduate papers. This represents a shift compared to undergraduate papers. The profile seems to imply that the focus in postgraduate papers is on developing the skills of *translating* conceptual *understanding* into procedural *practice*.

If the above interpretation of the postgraduate profile is correct, it is appropriate to classify procedural application as a higher order activity and, thus, a form of critical thinking. The ability to translate conceptual knowledge into application is one of the skills that is to be expected in postgraduate studies. Even so, the absence of further critical thinking skills remains difficult to explain. On the basis of the analysis in this thesis, the conclusion has to be that there is scope for broadening the higher order skills spectrum of postgraduate students. Without developing the full spectrum of critical thinking skills, the highest order of thinking, i.e. metacognitive knowledge, cannot be reached.

But, precisely how to evaluate the skill of apply remains a tricky question.

6.3 When is Apply a critical thinking skill?

Before a general conclusion, based on the analysis in this thesis, can be drawn, the question how to evaluate the skill of application has to be revisited.

In preceding chapters it was indicated that the skill of apply lies on the border of lower and higher order thinking. This is because of the dual nature of apply – either in the form of execution (of a set recipe and, thus, a repetitive routine), or in the form of implementing (and, thus, requiring some form of a design activity which originates in the person of the implementer). The latter version of apply is clearly a higher order skill.

The analysis in this thesis has shown that all incidences of application were of the execution type. On the face of it, therefore, it should not be included in the critical thinking profile of the examination papers.

But the skill of apply is not that easily categorised. In its essence, the skill of apply (unlike any

of the other skills) describes a move between abstraction and practice. It is inherently a translation from one knowledge type to another. Even when simply executing a set routine, it is possible that the conceptual knowledge which is the starting point, or the procedural implementation, or both, may be of such a level of complexity that merely executing a routine may require higher order thinking. To determine whether this is the case requires in-depth subject knowledge for a specific paper – which falls outside the remit of this thesis.

Based on this consideration, it was decided in this thesis to accept the skill of apply, even in the mode of execution only, as some degree of higher order thinking. The fact, however, that no incidence could be found of apply in the mode of implementing, as well as the absence of evaluation and analysis, and the scarcity of create, led the thesis to assign a lower weight to apply across the board.

On the basis of the second consideration in 6(b) above, the cross section between apply and procedure (C3) is accepted as an incidence of critical thinking.

6.4 Overall critical thinking profile

Given all the considerations in previous points, a graphic profile of the incidence of critical thinking in the analysed examination papers can be now be given. The profiles in the graphs below rest on an aggregation of all papers that were analysed. In other words, the intention is to provide an overall picture.

The first two profiles differ in terms of reflecting, or not, the presence of apply as a critical thinking factor. In the third graphic only the higher order skills of analyse, evaluate and create are included.

The first graphic (assuming apply to be a critical thinking skill) shows a relatively healthy presence of such skills. It is only relatively healthy because of the notable absence of the skills of analyse and evaluate across all papers. Even so, if one accepts application of procedures in the mode of execution as a legitimate demonstration of critical thinking, on a percentage weighted basis no less than 30% of all questions should then be classified as critical thinking.

The third graphic shows that, once apply is disregarded, a very small number of papers actually contained questions that could be coded as requiring critical thinking.

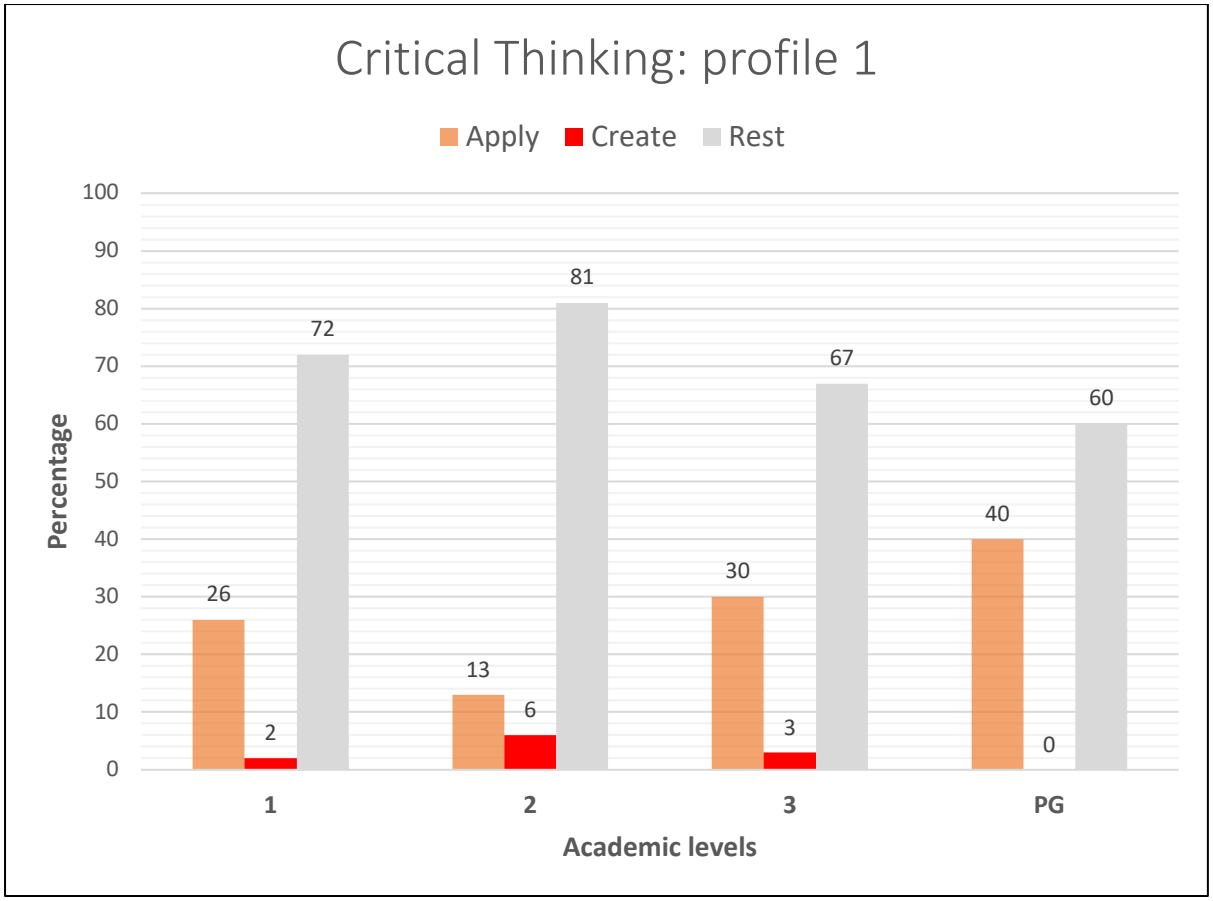


Figure 6.1 – Critical Thinking – Profile 1

The second graphic is based on a stricter definition of critical thinking skills.

But if one reserves the skills of create, evaluate, analysis, and apply only in the mode of implementation as legitimate demonstrations of critical thinking, the picture changes dramatically. In this case only a weighted 4% of all questions at undergraduate level may then be classified as critical thinking. The outlier is, of course, the 40% at postgraduate level, based on the interpretation provided above.

But even including the postgraduate factor, the overall weighted percentage of questions stands at 13%. This is, obviously, a more acceptable score, but debatable for the reasons discussed above.

What the second graphic does demonstrate clearly is the general skewedness of critical thinking skills across all papers and years. There is an over accentuation in the area of apply, and an underrepresentation in the important skills of analysis and evaluation.

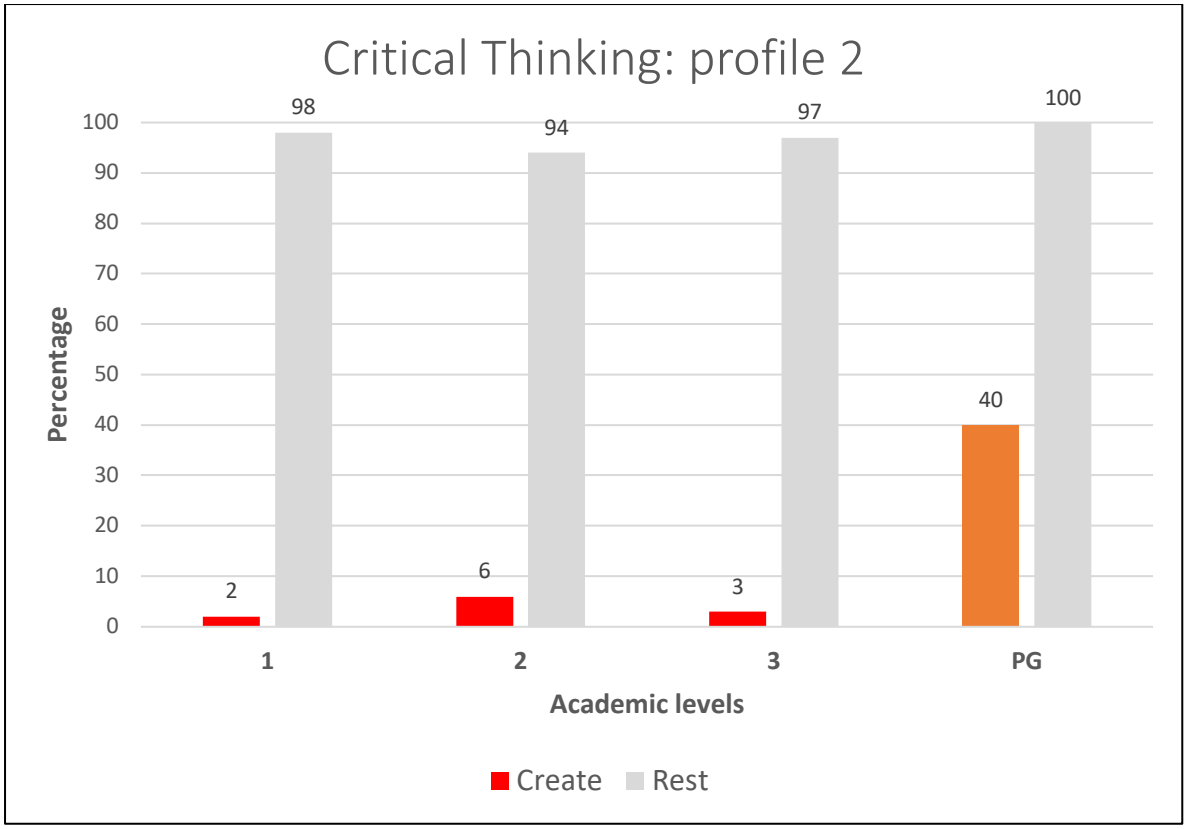


Figure 6.2 – Critical Thinking – Profile 2

Another way to look at the profile is to ask how many, out of the total of 64 papers, contained questions in the category of higher order thinking (in this case excluding apply in the mode of execution). The result is that only 11% of all papers, spread over 6 academic levels, fall in this category. And it must be remembered that none of the postgraduate papers are in this group.

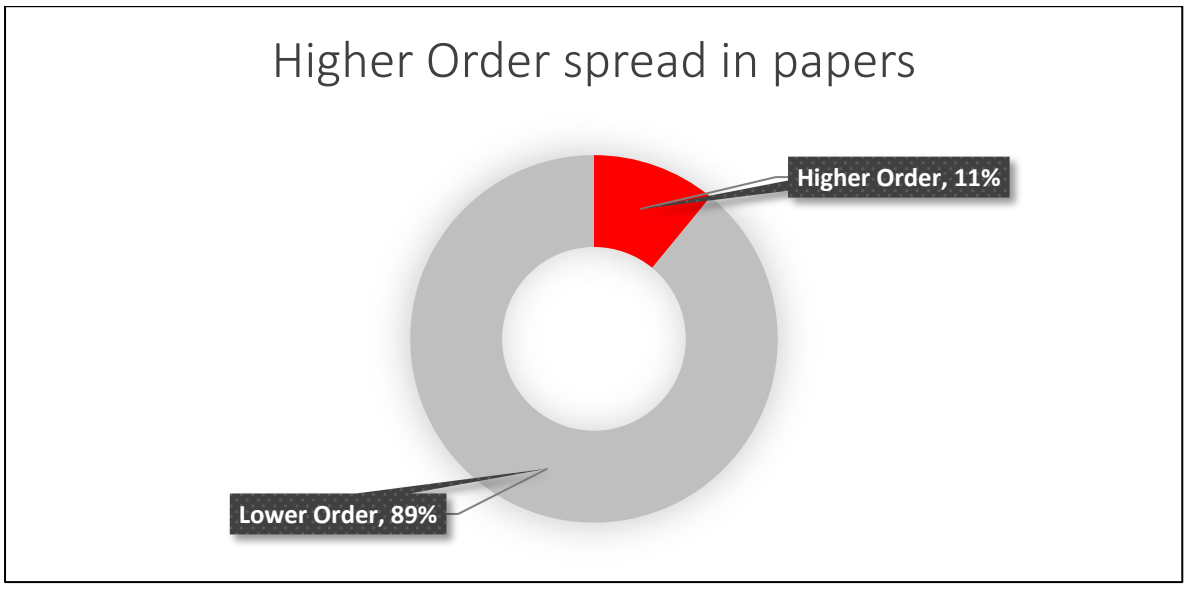


Figure 6.3 – Papers with Higher Order questions

From the data presented above there are two conclusions that can credibly be made.

Firstly, regardless of the weight accorded to the skill of apply, it is clear that the higher order skills of analyse, evaluate and create are underrepresented across all papers. Even if the skill of apply is recognised as acritical thinking skill, there is still an underrepresentation of critical thinking skills in the papers. Given the purpose of the specific institution it is understandable that there is a heavy emphasis on developing skills in the area of application, but it should be expected that at least at higher academic levels such skills will be complemented with other higher order skills. Without at least the skills of analysis and evaluation application skills may easily become robotic. Overall, then, the critical thinking profile is not only rather small, but also skewed.

Secondly, the data shows that there is an absence of progression from lower order to higher order (if not the highest order) of thinking skills. The same is true for the different types of knowledge. Across all academic levels there is a concentration on B2 and C3 factors. The differences between academic years are marginal. The dominant knowledge type remains conceptual and procedural, and the dominant process skills remain understanding and application.

6.5 Limitations

How should the profile presented in this thesis, and the conclusions above be evaluated? Three perspectives on this question seem to be important.

Firstly, critical thinking skills are not the only, and perhaps not even the majority of intellectual skills that an educational system is expected to inculcate in tertiary students. They should also not be viewed as more important thinking skills than any other. The fact that critical thinking is seen as advanced thinking, does not mean that it is superior thinking. As is very clear from the theoretical description of Bloom's taxonomy, there cannot be any higher order thinking if it is not rooted in solid lower order foundations.

It is, however, broadly accepted that critical thinking skills are necessary for strategic planning, innovation, and leadership in competitive environments. In times of change the ability to be creative on the basis of solid analysis and evaluation is a competitive advantage to societies and organisations. And it is generally accepted that we live in times that are in need of such abilities.

In general, therefore, when evaluating the results of this study, it must not be done from the

assumption that exam papers ought to comprise only critical thinking questions. An approach more in line with Bloom's paradigm dictates that exam papers, in general, should be designed to cover all 4 types of knowledge, and all 6 knowledge processes. This may not necessarily be the case in each paper, but the logic of Bloom's taxonomy implies that a spread over all components be visible in aggregate. It is also reasonable to interpret the Bloom's framework in such a way that one expects lower level courses to predominantly tilt toward the lower order skills, with a gradual shift to higher order skills in subsequent years.

This thesis focused on critical thinking skills, indeed. But it did so within the bigger context of the entire Bloom's framework. In that view it is not only a question as to how many higher order skills are seen to be operative, but also what the broader skills context is within which they exist. Profiling critical thinking skills as a proportion of all skills, at the same time sheds light on the total skills package.

Secondly, how generalisable are the findings? Restricting the analysis to only year-end examination papers means that only one instance of learning was investigated, after all.

This thesis is well aware that any profile of critical thinking skills in an examination paper cannot *automatically* be seen as a full equivalence to the content of the underlying coursework. It is in the nature of the subjects that feature in this study, that much laboratory and/or practical work is done during the duration of the course. Much of these cannot be replicated in an examination paper. In addition, there are periodic tests during the academic year that may be structured differently from the examination style and content. To comprehensively determine the proportion of academia that may be classified as critical thinking in a specific course, all of these activities have to be evaluated.

However, a final examination of any course or subject holds a special position in all programmes. Such papers are generally seen as representative of the *core* objectives of the guiding curricula for the courses they examine. They are widely taken to reflect the basic DNA of a course and treated as the most important summative assessment. It is for this reason that examination papers are centre pieces of external examinations. Although, therefore, a direct correlation between the course and the final examination cannot be claimed, a core and substantive correlation must be assumed.

After all, thinking skills are not restricted to any specific learning activity. All learning activities require thinking skills. The question is: what particular skills does a lecturer want a student to apply to the particular learning activity? To answer this question almost any dipstick

probe into a course will yield an answer, provided a robust instrument of analysis is applied. Doing so with respect to the learning activity of year-end examination papers is probably a more reliable probe than any other one.

Still, it must be conceded that the ideal would be to cover more learning activities during a course, as well as involving subject experts in the coding process. It is, after all, in everyone's interest to enhance tertiary education by means of higher order thinking practices.

6.6 The contribution of this thesis

This thesis is an academic contribution to the discourse in Botswana around the need to improve the applicability of skills in an evolving modern economy. The thesis contributes in that it accentuates the perspective of critical thinking in the overall package of thinking skills that an education system should deliver.

Possibly more significant than the specific analysis that was presented I this thesis (given the caveats and limitations described in the previous point) is the construction of an instrument to analyse and profile critical thinking in an academic context. The application of the instrument in this thesis demonstrates that it is a useful tool to bring standardisation to attempts to profile actual critical thinking skills in tertiary education (and in fact any education contexts where critical thinking may be legitimately expected). The standardisation makes it possible to apply the same tool to all tertiary institutions, not only in Botswana, in a way that allows for comparable results.

Bloom's taxonomy is very widely used in the development of curricula and in planning learning objectives as well as material for courses. The use of Bloom's taxonomy in the reverse, from the end point of learning back to the input into a course is far less developed and far less experimented with This thesis demonstrates that the use of the taxonomy for this purpose is a worthwhile activity.

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